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The Space Shuttle Orbiter

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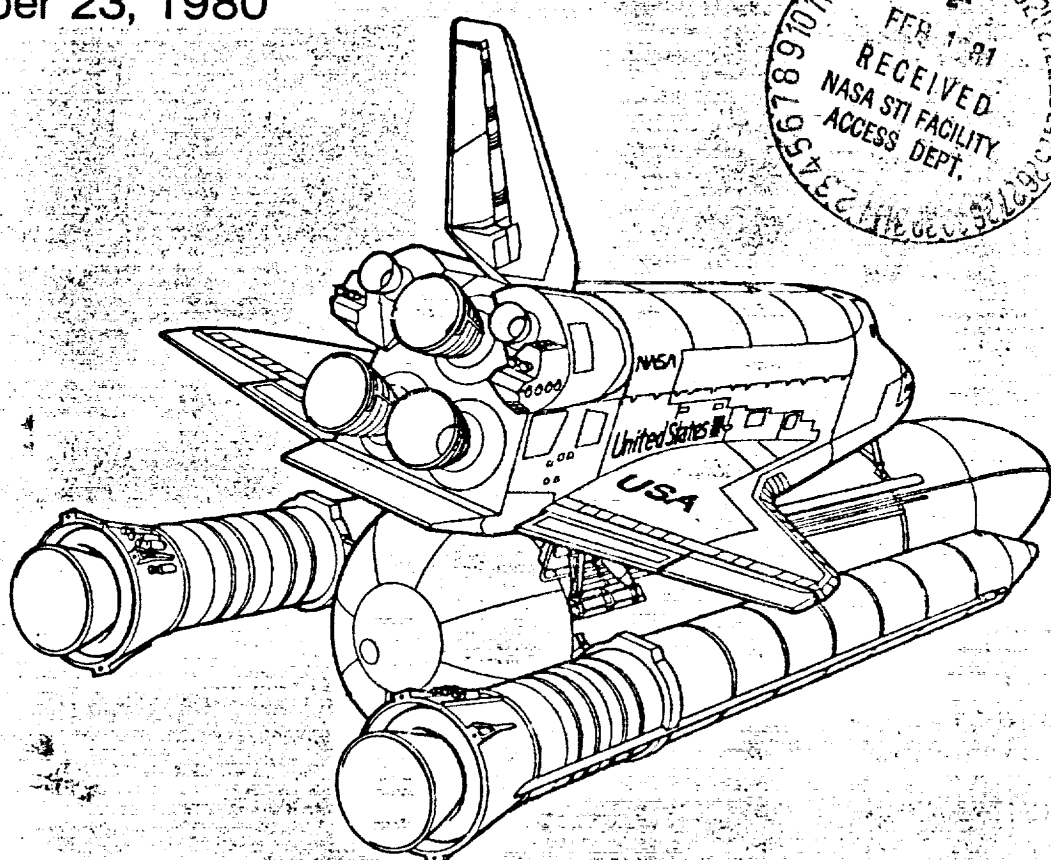

Space Transportation News Briefing

"The Orbiter"

Johnson Space Center
Houston, Texas

October 23, 1980

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SPACE SHUTTLE STATUS REPORT

Tuesday, Oct. 21, 1980

Orbiter

Orbital Maneuvering System pod interface tests remain in progress and should be completed today or Wednesday. Testing of the Extra-Vehicular Mobility Unit and Air Data Probes has been completed. The EMU is located in the airlock between the crew compartment and the payload bay and is to be used to provide life support hookups for the crew during tethered extravehicular activity. The Air Data Probes are mounted on rotating doors and provide information on airspeed during atmospheric flight. The input/output processor for General Purpose Computer No. 4 and TACAN No. 3 were also replaced.

Tiles

During the week ending Sunday, October 19, 660 tiles were bonded to the vehicle and 99 were removed for a net gain for the week of 561. The number of cavities remaining on the vehicle is 1,552 and the number of estimated bonds to completion is 2,320. During the week, 1,081 proof tests were conducted with only 4 tiles rejected.

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External Tank

The External Tank was powered up to support development flight instrumentation testing on Monday. Preparations for mating of the External Tank with the Solid Rocket Boosters are in process today.

Solid Rocket Boosters

Preparations for mate of the Solid Rocket Boosters with the External Tank are virtually complete. Paperwork closeout is underway.

Recovery

The UTC Liberty, first of two solid rocket booster recovery ships to be delivered to KSC, was scheduled to leave the Ft. George Island shipyard of Atlantic Marine at high tide (about 12:30 p.m.) today for the 12-hour run to Port Canaveral. The Liberty is to enter the port and near the locks into the Banana River at about 8 a.m. on Wednesday and will pass through the locks and move up the Banana River to Hangar AF during the morning. Arrival at Hangar AF is scheduled for about 12:30 p.m.

Space Shuttle Main Engines

Modifications to the engine pre-burner units should be completed by Wednesday and all three fuel pumps should be back in the engines by Thursday. Work is on schedule for reinstallation of the engines in the orbiter on November 8-9.

Pad A, Complex 39

The hood and tip assembly (beanie cap) for the External Tank Gaseous Oxygen Vent Arm is to be delivered to the pad on Thursday for installation on the Fixed Service Structure.

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GPO 874-178

MR. GORDON: Good afternoon ladies and gentlemen at here, Washington, KSC, Marshall and DFRC, hopefully. We have with us this afternoon Mr. Aaron Cohen who is manager of the Orbiter Project for the Space Shuttle Program Office at the Johnson Space Center. To bring you up to speed where we are in the program today, we are completing the fourth full duration simulation today at the Johnson Space Center, hopefully to make the final burn of the OMS of the RCS system at 2:20 this afternoon, with a landing hopefully at 3:24 of all simulators. The next event in the program will be the cluster firing of the three main engines at NSTL now scheduled for November 3rd. Rollout is still set for November 23rd of next month. Mr. Cohen will go over the Orbiter and I'll turn it over to Mr. Cohen.

MR. COHEN: Good afternoon. The launch of the Space Shuttle Orbiter -- the Space Transportation System -- in March will herald a new era in space transportation. And I'm going to show you some charts today, some of you have seen before, but I'm going to start off that way because I want to make a couple of points that maybe have not been made before.

Let me have the first chart please. (Slide 1) The chart on the screen shows how the Shuttle operates. Many of you have seen it. The key caption here, the key issue here, is reusability. Reusability of a space transportation system. The previous vehicle, previous space flights -- Mercury, Gemini, Apollo -- one use. Here we're talking about a reusable system. And, as you see, you launch with the Solid Rocket Booster, the Main Engine, the External Tank and the Orbiter; you separate the Solid Rocket Booster; they're recovered and reused; the External Tank is separated and is not reused; then the orbital maneuvering system puts the Orbiter into Earth orbit; and then you complete your orbital mission. You go into orbital insertion and then you go into orbital operations. You open your payload bay doors. You do the various activities you have to do in orbit, such as retrieve or deploy satellites, scientific experiments; you close the payload bay doors; you retrofire with the orbital maneuvering system engine; you reenter; you land; you service; you turn around and you fly again. This is, of course, the big difference from the previous manned space flights. What can you accomplish with that on the next chart, (Slide 2) and again, you've seen this, the operations -- there are wide variety of operations as you can tell from the chart. You can deliver and place in Earth orbit satellites, propulsion stages, retrieve expensive payloads for reuse, service or refurbishment of satellites and so forth. And the applications are broad to various different forms of operations of Earth resources, laboratory and research, satellites or astronomy, communications, navigations and so forth. So the Space Transportation System really opens up a new era. You might say it's a little bit like the Wright brothers in space flight.

The advantage, of course, of having a manned Space Transportation System is on the next chart, (Slide 3) where you can actually have the crew go extravehicular to perform various functions that you couldn't do in an unmanned vehicle. You have a remote manipulator system, which I will talk about in some actual pictures in operation of the remote manipulator which can be operated from the crew from the aft station of the Orbiter. So this sets the stage of what the system is built for and what it can do. I'm not going to talk much about that today. I'm really going to talk now on how the Orbiter works and its complexities and how we're doing on it. On the next chart (Slide 4) you see a chart that many of you actually saw, the actual flight, the 747 and the Orbiter in 1977. It flew our approach and landing tests. The significance of this test is really one of the basis behind the complexity of the Orbiter. The Orbiter is the brains of the whole Space Transportation System and in that brain is a data processing system. The data processing system, the multi-functional computer operation, was verified in the approach and landing tests. The flight control system, its subsonic regions, the handling qualities of the Orbiter, the hydraulic system, the landing system, basically were verified in the approach and landing tests. And when I talk about the details of the avionics system, I can show you what I mean by the complexity and what we proved in this flight. You might keep that in mind when I talk in detail about the total avionics system.

There basically were three, you might say, state-of-the-art advancements that were needed to be accomplished in order to make the Space Transportation System work. One was the avionics system, which I'm going to talk to you about; the other is the thermal protection system, which I'm also going to talk to you about; and the other is the main engine, which I believe has already been briefed and I'm not going to discuss. So two items really pressing the state-of-the-art when we decided to go forward with the Space Shuttle Transportation System.

On the next chart, (Slide 5) again is a familiar one for us working on the Space Transportation System, shows the Orbiter, the External Tank and the Solid Rocket Booster strapped alongside. The point really to make here is that the Orbiter here is really not only a spacecraft, but the Orbiter is, it has the spacecraft and has the brains to control the other elements and decide what to do, but the Orbiter also is a launch vehicle, and it also in some regimes operates like an airplane. So what you're really talking about is a system of vehicles that is launch vehicle, that is spacecraft and that is an airplane. And now what I'm going to do is develop for you the systems that are used in the Orbiter to function for those three applications. The other point to make is the size, which I think many of you have seen the vehicle at the Cape or at Palmdale. It's approximately 125 feet long, has a wing span of about 78 feet. And then, of course, the payload carrying capability is the so-called mid-bay here, the payload bay which is approximately 15 feet by 60 feet long, the payload bay doors that open for the operation of putting -- of deploying or retrieving payloads.

On the next chart (Slide 6) shows the, basically the structural layout of the Orbiter. When we decided to design the Orbiter we decided to go with a conventional airplane type structure, aluminum skin-stringer or type construction which most of the aircraft is, and I'm going talk about those exceptions in a moment, but basically the wing, the mid-fuselage, the forward fuselage and the crew cabin, the vertical tail, the aft fuselage, are basically aluminum skin-stringer structures that have to be maintained at 350 degrees Fahrenheit. And that's, of course, the reason for the thermal protection system. Then where we deviated from that -- the payload bay doors -- we did go to graphite epoxy for weight saving and that's very large -- as John Yardley told you -- it's one of the largest pieces of graphite epoxy made. And so the payload doors are made of graphite epoxy. The OMS pod, which is hard to depict on this chart, is also made of graphite epoxy. And in the thrust structure area that takes the thrust carrying of the main engine, we make out a fusion bonding titanium. So those are really the basic differences than the conventional structural airplane. The leading edge is, of course, the carbon material, which again, I will talk about later and in those areas, and of course, the thermal protection system. So that is basically the Orbiter structure.

Now in certifying the Orbiter, which we'll see on the next chart, (Slide 7) we basically built a vehicle to print. This is another vehicle that was built just like 102 at KSC, right at the moment, this happens to be called OV 99, and we went through a structural test program on this vehicle. And basically, what you do with this, you have different loads defined and you have various load-carrying jacks that actually put loads that are computer-driven and you essentially fly this vehicle, this test article, in this test frame for various loads, to prove out the structure of the vehicle. Now we do have an innovation here, where we did not go to ultimate. We took this vehicle to 1.2 times limit and built various members that we were concerned about and took them to ultimate and essentially used this vehicle as the second orbital flight vehicle, which now, if you go to Palmdale, you see this being readied for the OV 99 vehicle or the second orbital flight vehicle, which again I will talk about in a little while. So that is the structural aspect of the Orbiter.

The next chart (Slide 8) shows a very important element that is needed in the operating the Orbiter and that's the forward reaction control system, and that's the pod that it's in, and the aft reaction control system along with the orbiter maneuvering system engine. The use of this, the use of this system of the forward is primarily used for separation of the Orbiter from the External Tank and used in orbit to control the Orbiter around its center of gravity. The aft RCS system is also used in Earth orbit to control attitude control and is also used during entry. At some point and time in entry the aero surfaces are defective, the airplane part of the vehicle, is not effective, and you have to use the reactor control system for control. And of course, the orbital maneuvering system is used for insertion into orbit and retro and for changing your position in orbit. These systems, the forward, the aft pod here, have all been certified at our White Sands test facility. We've gone through numerous firings of this total system very similar, if you're familiar with, very similar to the total engine firing, main engine firing at the National Space Technology Laboratories. We did this systems firing at our at our White Sands facility in New Mexico. You look at the vehicle today, the Orbiter vehicle today, these pods, the forward and the aft pod are all installed on the vehicle and have just completed their final checkout.

The next chart (Slide 9) shows the aft propulsion stage, the engines of course, we've already talked about in previous discussions, the Orbiter portion is the plumbing, all the plumbing in the aft end of the vehicle, the regulators, the valves that control the propellant flow from the External Tank of the liquid hydrogen/liquid oxygen into the engine. This system again is part, you might say, of the booster part of the Orbiter. These systems -- this system right here -- has had a great deal of testing. Every time you do a firing out at the, out at NSTL, for the main engine at Mississippi, the Orbiter systems get a very detailed system verification. Now, if you look in the aft end of the Orbiter today, at 102, of course all this equipment is installed and has been checked out. We checked, the functional tests have all been run on the vehicle.

The next chart, (Slide 10) you might say, is the spacecraft part of the vehicle. The spacecraft is the environmental control and life science subsystems. Here you have basically the cooling system that exchanges the heat that is generated, the electronic system, you have heat exchanger, you have the payload bay door radiator which rejects the heat in outer space, and then you have various cooling, flash evaporator and ammonia boiler for areas to dissipate heat in the aft end of the vehicle. Then you have the nitrogen and oxygen system which actually supplies the cabin environment to the flight crew to maintain the vehicle in a so-called shirtsleeve environment. And then you have the food management and the waste management. That, you might say, is similar type hardware, a little bit more complicated, but similar type hardware but basically it's flown on previous spacecraft except for things like the radiator doors. But this system, again if you see the vehicle, this has all been installed in the vehicle and checked out in the vehicle at Palmdale, and had numerous tests at the contractor and at the Johnson Space Center.

The next system, again is a spacecraft system, you might say. It's the electrical power system (Slide 11) which, again, is not different really than we did on Apollo, which is the fuel cell system. We have oxygen-hydrogen doors that carry the propellants for the fuel cells and, of course if you look at the tanks in Apollo versus the tanks in the Orbiter, they're much larger but bascially the same type of function is performed. Again, if you look at the vehicle, you see that this is all installed in 102 at Kennedy and is in the process of its final checkout.

The next chart shows the hydraulic system. (Slide 12) You might say this is the airplane part of the system. This is a system different than we had used in our previous spacecraft system. Here you have three independent hydraulic systems. In their power you cannot use the fuel cells for their power, you have to have power from an auxiliary power unit, which is a terminology you may have heard before, the APU or the auxiliary power unit. It's a 325-horsepower turbine driven units, the speed of the turbine wheels like 72,000 rpm and they essentially supply power for the hydraulic system which moves your aerodynamic surfaces at the appropriate time and your vertical stablizer, your speed brake, your landing gear system, and your brake system. This system is, again been checked out on the vehicle, many hours on the vehicle, all installed, and over and above that we have a flight control hydraulics laboratory at Downey, at Rockwell where we run almost continuously to check the various temperatures and pressures and performance of the hydraulic system, the so-called iron bird which is familiar to airplane technology.

Now getting into a system that I call the brains of the system -- may I have the next chart (Slide 13) please -- this is the guidance navigation control system. When I said the brains of the system, this is the brains of the system. On the approach and landing tests, which I talked about previously, this was included in the approach and landing tests of the Orbiter. To spend a few moments in describing this, the heart of the avionics system, of course, is your four synchronized computers. That's the heart of the system, let me say the brains of the system. These computers are synchronized and essentially they talk to each other 350 to 400 times a second. One computer is designated as the boss or the lead computer, and basically sends the commands, receives the commands, does the computations and sends the commands out. But before he does that, the other three computers actually do the same thing and vote. If he should be wrong, its voted out of the system and the next computer takes over and does that function. Should we have a problem with all four computers, then we have a identical backup computer, which is outside the redundant set, which can do the same function. Now that's basically how it works. Now let me talk a little bit about, I talked about the other system, but let me talk to you, let me explain a little bit more on this chart how those other systems work. Let's see if I can tie the other systems in for you with this system. First I talked about, first let me talk about the information that comes into the computer to determine some things. You have the inertial measurement unit which gives you basically attitude and velocity once you do the computations in the computer. You have rate gyros which give you attitude. You have accelerometer assemblies and their data which gives you data during certain air data portions, although the inertial measurement unit isn't as good, you get raw air data. Then you have the microwave landing system, TACAN, radar altimeter, of course rendezvous radar we're not flying on this flight. This information all comes in in an analog form into a series of multiplex or demultiplexers which in simple terms are analog to digital converters. It converts the

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information from analog to digital information. It comes into the computer, the computer does its algorhythms and does its computation, and then sends out information to the RCS system. I've talked about the reaction control system. So it sends information to tell the reaction control system when to fire, when not to fire and how long to fire. It also does the same to the orbital maneuvering system. It also does the same thing to the aero surfaces. So the algorhythms take the data and determine what muscle and what driver should be used in order to maneuver the vehicle. And during ascent it does the same thing to the SRB, solid rocket boosters and the main propulsion system actuator. So this, when I say the brains, I've talked to you about these systems, the main propulsion system, the orbiter maneuvering system, reaction control system, and this is how they're tied in with it. Now the, then it gets a feedback from what this system does and then the crew can also use the display driver units to call up information from the computer from the display keyboard and essentially have the data display on the cathode ray tubes of the CRT and can actually use the keyboard to call up various programs. So when I say the brains, this is the brains of the system. When we flew ALT, the approach and landing tests, we were very concerned technology wise, were we really able to tie this together. Were we really able to tie a four-computer system together in a redundant fashion in order to be able to do this job that I just described in this chart. As it turned out, we were very successful, extremely successful, in fact if you recall, one of the first free flights we did essentially lose a computer. We didn't like it, but it proved that you can vote a computer out and take over just as we had laid out. But the point really being the approach and landing tests really was a big forcing function to get this brains done, or accomplished, I should say.

Now to talk about the thermal protection system. (Slide 14) The other technology or state-of-the-art issue that was a challenge. When we started the program we felt very strongly that the leading edge of the so-called RCC is -- I'm going to show you a little later -- was really going to be a technology issue. It was an understanding of a very high temperature material. It was a hand-crafted material. It turned out that we accomplished that in a very good fashion. And that has to take temperatures of greater than 23, 2,400 degrees Fahrenheit. That's on the leading edge of the wing and forward nose cap area as you see there. The other material was the flexible reusable surface insulation which was basically Nomex material and then we come to the so-called LRSI and HRSI, the low-temperature reusable surface insulation material and the high-temperature reusable surface material. The real difference -- I'm going to concentrate on these two, the low-temperature and the high-temperature -- they're basically the same material. They're made out of sand essentially, fused silica, and purified sand. The only difference between the two of them is one has a white coating, the other has a black coating. One for, ah, to give you the right alpha over epilson, for reflection and absorption. Now we were really -- and you can see by this chart -- where the various materials are laid out on the vehicle and I'll talk a little bit more about that later on.

Now the technology in this you have to appreciate -- if I could have the next chart (Slide 16) please -- the technology of this was the fact that we were going from a non-reusable ablator material in previous spacecraft to a light-weight reusable material. We were going to a material that essentially has about the weight of balsa wood. We're going to material about 9 pounds per cubic foot. Now we do use some material that's 22 pounds per cubic foot, but basically the vehicle has 9 pounds per cubic foot thermal insulation on it. To talk a little bit of the build of it. How do you build a tile? Of course, that was the first technology issue that we had to overcome, is the building of the tile, getting the purity, the thermal conductivity and so forth, and the way we built it, basically a tile in this point and time, how we built a thermal piece of material -- I'm going to get to why we call it a tile in a minute -- why we built a piece of material, ah how we built a piece of material this way. We get sand; we purify the sand. That's done by Johns Manville and they come out, Johns Manville then pulverizes this into a quartz type material -- its a fused silica -- and then that is shipped to Sunnyvale, Calif., to Lockheed and they go through a process that essentially puts this into a block of ceramic. It comes out in what we call production units; a block of ceramic. And then we have to measure conductivity, thermal conductivity -- and so forth -- the characteristics of that material. Once that was done we had to figure out the contour of the vehicle. Now what we wanted to do was make the vehicle as... without as many complicated lines as possible, but as it turns out, for aerodynamic purposes you cannot always do that. So this became a descriptive geometry -- I don't know how many people have taken descriptive geometry -- but this became a descriptive geometry problem and laying out tiles to fit the contour of the vehicle. Now, and that turns out to be quite a few number of tiles with different shapes because we did want to minimize the weight. To give you an example: about a five-thousandths thickness of the surface of the tiles are put on is about 500 pounds. So it is important to contour or make the thermal protection system is to the right dimensions. Once we laid all that out and had that done, you had to machine it very accurately because, as you see, that the material is a ceramic material which basically has zero thermal coefficient of expansion. And that has to be put onto a material like aluminum which has thermal coefficient expansion. So in order to take care of that, we came up with bonding it to a material which is called a strain isolator pad or SIP, we call it, which is basically a felted Nomex fiber material, which would allow the coefficient of expansion between the basic structure and the tile to be compensated for. Now we also found in our analyses and tests that you... that really, you shouldn't put this on too large an area because of this difference, so our study showed that six by six was basically about the right dimension to have for the tile to handle this type of coefficient of expansion difference. So out came approximately 30,000 tiles. And that's where the word tile really generated from because you had to put on in segments rather than enlarged sheets. Now when you put a tile on that way, you then have to... you then have to be sure you take care of the distance between the tiles, the so-called gap, and the height between the tile, the so-called step because if those aren't controlled to accurate tolerances you can get a tripling of the boundary layer and get excessive heating. So that leads me to the point where once we laid this out -- the dimensions of the tiles out and the contours out -- they actually had to be machined accurately. And by accurately I mean they had to actually be numerically control programmed on machines and actually machined. So we accomplished that, we accomplished all that and then we found that the basic tile strength, the basic LI-900 tile strength was approximately 13 pounds per square inch. The LI-2200 tile was approximately 35 pounds per square inch. Now there was a very subtle difference, we found a very subtle thing that happened that when we did a number of laboratory tests, we found we were getting a variation in the tile strength lower than the basic tile material. In other words, if you look into a number of plots and distributions, or a number of plots and number of samples, we found we were actually developing about half the total strength of the tile. In other words we were not failing the... we were not failing the bond. We were failing at the bond line but due to the stress concentrations that this felted Nomex provided, it caused stress concentrations in the ceramic material and essentially decreased the strength to about 6 1/2 pounds per square inch for the LI-900 tile, or for about 17 1/2 pounds per square inch for LI-2200 tile. You might say that necessity is the mother of invention. We were able to come up with a quick technique which we called a densified layer. What this densified is in simple terms is basically liquid glass which we impose and lower tenth of an inch in this tile and essentially with that we are able now to develop the full strength of the tile. So we were able to take out the stress concentrations with this technique. So we did -- so you may hear the term densified -- and that's what that means. We densified the tile so we were able to take out the strength at the stress concentrations. The other thing we found is that there is a variablity in process and there is a variability in the strength of a ceramic material which said that some way once we had tiles installed on the vehicle whether they be densified or undensified had to really understand what we had. So we came up with what we called a proof-test technique.

And on the next chart (Slide 17)... let me make one more comment before I go on to this chart. I can talk to... you can leave this chart up but one other comment that's important to make is the technology of the state-of-the-art and actually calculating the loads of the tiles is very complicated. The loads on the tiles, by that I mean both aerodynamic... whether its aerodynamic loads, vibroacoustic loads, aero shock loads, thermal... loads due to thermal deflections, whatever they may be, have to be put together in a very complicated fashion and have to be in a different for each tile, shall I say, or certainly for each region of the vehicle, for each tile and for each regime of flight. So this became a very complicated process of understanding the loads, the detailed loads on the tiles. And of course, as you might expect, we are conservative in our loads and we plan to stay that way. Now in order to insure ourselves both quality and, for both the quality aspects of it, like putting the tiles on the vehicle, and for the characteristics of the material themselves, we developed several things. One is what we call sonic testing the tile. We actually, before we put a tile on, can pass, without a destructive test, we can pass the sound wave through tile and actually determine how much strength or how much load the tile can take. We can actually determine whether -- because ceramic is non-uniform -- we can weed out, you might say, the weak tiles before we actually put them on. So we can determine whether we truly have a 13-pound-per-square-inch tile or 20 or less, and if it's less, of course, we don't use it. Once they're on the vehicle we also have a technique where we can actually where we can actually proof-test the tile. We actually have a vacuum shop. In this case we're testing some of the so-called mini-tiles and we actually put a calibrated load to determine whether the tile can take its strength, of the loads that we have to see. And normally we test a tile to 1.25 times its limit stress that we'd see in going through this detailed calculation of the loads I just explained. There's another way of doing it -- on the next chart please -- there's another way of doing it -- I think that chart really should be rotated... can you rotate that 90 degrees, that's good. What this is doing is actually proofing the tile after it's been bonded to the vehicle. What we do is we figure out what the load... what load will that tile see in flight. Once we determine that, we essentially proof it to 1.25 times that load. And we found that we had to do one more thing. We had to actually... by proofing it, you essentially... by proofing it you could essentially do some damage. I mean it's not all good. So what we did, we calibrated this in the laboratory on a number of specimens where we actually have acoustic emission devices in this head here that actually does the proof-test on the tile, and we actually have that calibrated to a noise level to determine whether we actually have a good tile or a bad tile. So that again is a terminology called acoustic emission testing of tiles. Let me have the next chart please. (Slide 18)

This is the underside of the vehicle. We sometime ago made a decision to densify several thousand tiles. This is a point in time where we actually did decide to take some tiles off and go back through a densification process, that I just showed you, in areas where we were concerned about some loads. Today, if you look at the vehicle, today if you go there and look at the vehicle as of this morning, we had 1,286 tiles left to put on the vehicle. That's as of this morning. So this picture... this is the underside of the fuselage, mid-fuselage, and you can see the individual tiles at this point in time, you can where they're some tiles we're taking off the vehicle. This is all filled in now if you look at the vehicle.

The next chart... I'm actually now... we'll talk about this. This, for the people on the net, you do not have this chart. This is the only chart you do not have. It's not in your handout either. It's one I put in. I wanted to show you just what a picture, and he apparently left it out, the picture of the leading edge and what it is. It's a carbon carbon of the wing leading edge segment. There's some, I believe, 20 some odd sections -- and I may be wrong -- some 20 sections or 30 sections of this on each side of the wing. And this is called the wing leading edge section carbon carbon material that I talked about earlier. This takes very high temperature. Now, behind this carbon material, when it's installed on the vehicle, are also tiles. We do have tiles to take some of the... this gets very hot... it takes the temperature and the tiles essentially are the insulating material. So that's the story of the thermal protection system and that again, was to just reiterate the state-of-the-art that we had to overcome, was a lightweight reusable material -- I stress the word lightweight and reusability -- and the issue of really understanding how to key loads. May I have the next chart please. (Slide 19)

This shows you what the internal... this shows you what the internal cockpit looks like in the Orbiter. This is 102. I talked about previously the CRTs or the cathode ray tube, the display keyboard for the astronaut and the individual dedicated instruments. Again this allows the crew to interface with the brains of the system. This has gone through many hours of integrated checkout at Cape Kennedy. We have many hours of testing in our simulators here at the Johnson Space Center and in our Shuttle avionics integration laboratory and at the Downey simulator. So we've gone through many hours of checking out the hardware-software interfaces that I talked about previously. The tying the hardware, the software, the muscles together is... was quite a challenge.

Talk about a system now that is not flying on STS-1, but I thought it -- let me have the next chart (Slide 20) -- but I thought it would be interesting for you to see. This is the remote manipulator system. This is actually being built for the... for NASA by NRCC from Canada, the National Research Council from Canada, contracted to SPAR, and this basically is a... an arm, just to depict this for you. This is the shoulder. This is just like... this is very much just like your arm. This is the shoulder. This is your elbow and this is your wrist and this the end effector. Now, for the people on the net, as you go from the door back there, that's essentially the shoulder; as you come to the next joint, its the elbow; the next joint is the wrist; and the end effector. And that essentially has movement very similar that you have in your arm and is controlled with a hand controller... it's controlled with a hand controller from the aft station of the crew module. That is not going to be flown on the first flight, but it's scheduled for the third or fourth flight to be flown. The delivery from the Canadian government of that arm will be... take place the latter part of this year where we actually have our final acceptance review and buy off on the first arm this year. Of course, that has a lot of applications, as I said earlier, in terms of retrieval, deployment of payloads.

The next chart (Slide 21) just shows the display panel which is just a display panel for the utilization of this arm. May I have the next chart please. (Slide 22)

Talk a little bit now about where we stand in the STS-1 flow. We basically will plan to finish the tile completion. You might say, as I've said, we have some 1,286 tiles to put on the vehicle. So the tile completion is coming very well. We've had to make various mods in the OMS RCS area for some certification issues we had, some loads issues we've had, some auxiliary power unit issues we had in qual. We've really gone through a lot of systems testing. We've gone through an APU, an auxiliary power unit hot-fire, where we actually powered up the auxiliary power unit in the OPF and used the hydraulic system along with the flight control system. We're doing the structural integrity test now. We did a dymamic stability test and a frequency response test to certify the flight control system. Crew and equipment interface has been verified. Payload bay doors and radiators have been checked out and we've checked out the forward and aft RCS system. Move out of the OPF on November 23rd. We spend the time, about four weeks, in the VAB. Of course, we may with the other elements of the system, and we do test, an integrated test which is a key test in the VAB, then move to the pad where we do the typical type pad activities culminating, you might say, with the flight readiness firing on February 7th. That's basically the flow... that's basically the flow for the Orbiter. Next chart please. (Slide 23)

This shows the integrated flow for the STS-1 through STS-2, 3 and 4 and 5, the basic flow that's been laid out. I won't go through that in much detail, but here's basically the four-month period, the five-month period set up between flights. There are things that have to happen, on the next chart, (Slide 24) there are things that have to happen that we do have an upgrading for various things between STS-1 and 2. If we decide to fly a tile inspection repair kit, we'd install that. If we do decide to do that, there may be some more modifications. We'd have to move the DFI pallet. We would install the third cryo tank. There are some other minor changes in some of the flow from the VAB to the pad.

In the next chart (Slide 25)... again, similar type things, here the big thing is installing the fourth cryo tank set if needed and some other minor changes. So we do have some minor changes in between flights as we do for the next chart also.

Then when we go to the (Slide 26)... this is basically the same thing just showing what type flow you have in between the third and fourth flights. On the fifth flight you do make some modifications. You basically put the... here's the payload deployment retrieval test article that we put in for the remote manipulator system and basically get the Orbiter starting to get up to its operational STS... 102 up to its operational configuration.

On the next chart is the (Slide 27)... basically the follow-on vehicles. The next chart please.

The next chart (Slide 28) is what we call increment 3 or follow-on. I talked about 102. The mods for 102, OV-99 was the structural test article I previously showed you. It was delivered to Palmdale for... Rockwell Palmdale from Lockheed Palmdale and it's in the process now of being modified and built up, in fact, tiles are being bonded on that vehicle today. We are bonding tiles on the vehicle and planned scheduled delivery of that vehicle is in June of '82. One-O-Three is in its production phase now. That's the next vehicle and its scheduled for delivery in September of '83, and then the 104 vehicle is in its long-lead fabrication process and its scheduled in December of '84. So that rounds out the fleet we're now building for the... of the Orbiter for the Space Transportation System. That completes my prepared briefing and I guess now I'm ready to answer any questions.

MR. GORDON: Thank you, Aaron. Please wait for the mike and identify yourselves so we'll have it for the transcript. Any questions from Houston? Jules Bergman in front.

MR. BERGMAN: Jules Bergman, ABC News. Mr. Cohen, how do you verify all of what you've said with all the problems we've heard about the heat tiles? And the fact that they're so fragile, you touch them with your finger and they dent. Are they really going to be reusable for the 50 odd flights that the Orbiter's supposed to be reused for?

MR. COHEN: Well, first of all, the... there's no question that for the first flight we're being ultra conservative. That's number 1. Number 2, there are in-place repair procedures that if you do have a, you might say, a nick or ding in the tile, that it's very easy to repair a tile in place. So you do not have to take a tile off. It's a very... we have numerous, you might say, repair procedures for a dinged or damaged tile. So the issue of once you get into flight, are you going to have dings or nicks in the tiles, where are they going to come from. I don't know really where they're going to come from. We're probably doing as much damage on the ground as we would be once we get into flight, you know because...

MR. BERGMAN: My God, if you had a rainstorm it would be a disaster!

MR. COHEN: No, I don't... we've done tests with... we've done tests where we've actually impinged water or rain on the tiles and that's not really a...

MR. BERGMAN: And Mach 2 or 3 or 4?

MR. COHEN: We've had some tests like that, yes. Yes. Now, if you do have damage, it's now damage where you actually do replace the tile, it's damage where you repair the tile in place if you do have damage like that.

MR. BERGMAN: Sir, are you telling us that the heat tiles will last the 50 flights, which is the current number, I understand, of reusable flights the Orbiter itself is supposed to be good for?

MR. COHEN: What I'm telling you...

MR. BERGMAN: Without major replacements.

MR. COHEN: Yes, what I'm telling you is that we have in our budget for between flights, we feel that we'll probably repair or replace approximately 400 to 500, maybe as high as 600, tiles between flights. And that's what we're budgeting in our turn-around time. We can put on as many as 700 to 800 tiles per week. But we are budgeting in our turn-around time, maybe as up to 500 or 600 tiles that we may have to replace between flights.

MR. BERGMAN: I'm not saying turn-around time. I'm saying reasonably...

MR. COHEN: Yes...

MR. BERGMAN: How many tiles do you expect to be damaged between prelaunch damage, ice chunks flowing off the ET, launch damage, and reentry damage?

MR. COHEN: Well, I'm saying I feel that it would be like 500 to 600, maybe 700 tiles that will have to be replaced between flights. That's what I'm saying... that's the point I was trying to make. That's our best estimate right at the moment. That's... you might also have to do some repair... there are repair techniques for tiles. As I said, they're easy repair techniques that we can inspect the tiles and have an in-place repair that takes a few... a very few minutes to make a repair.

MR. BERGMAN: By in place you mean in orbit or on the ground?

MR. COHEN: On the ground. When you land... that's what I've been... you don't have to take the tile off and replace the tile. Very easy to repair and very quickly done.

MR. GORDON: If we have no more questions from Houston at this time, we'll go... excuse me, Warren?

MR. WOOD: I'm Warren Wood with TRW. Mr. Cohen, I wonder if you could just discuss very briefly how we arrived at the requirement for the flight readiness firing and what we really look to verify with the flight readiness firing.

MR. COHEN: Well, the requirement for the flight readiness firing is really... it's, you might say in simple terms, it's about all you can say... it's an end-to-end check of everything. You can't isolate one single thing that drives you to do a flight readiness firing. You have to say it takes you from one end of the regime, i.e, ground support equipment to servicing the system, the flow of the fuel, the firing of the engines and seeing everything operates, so it's really an end-to-end check before you get ready to fly and that's the major reason why you do a flight readiness firing.

MR. GORDON: Over here.

MR. NIXON: Steve Nixon, L5-Texas Newsletter. There have been some rumors that if the schedule for the launch gets very much further behind, Corgress might consider cutting the funding or something like that because they have doubts about the viability in the program. Is that true or...?

MR. COHEN: I actually ...I can't respond... I can't answer that question. I mean, not that I won't, I don't know the answer to it. I honestly don't know. Sorry.

MR. NIXON: There's no question about the viability of the program?

MR. COHEN: Well, not in my mind. I feel very comfortable with it. I feel like it's a very good system. As I was trying to point out, it's a very complicated system, but I think it's very well engineered and sound system.

MR. NIXON: You have adequate funding at this time?

MR. COHEN: At this time, yes.

MR. GORDON: We have one more, down here. Mr. Bergman.

MR. BERGMAN: This lady, here.

MS. HENCHLEY: Debra Henchley, New York Times. I've a question for you about the tiles. With all the concern about the use of the tiles and whether they'll be able to perform up to standard and with the questions about the budgeting of the first Shuttle, how come all the applications on the other spacecraft in the fleet are being made? How come you're applying tiles to them now also?

MR. COHEN: Well, let me see... I think I understand your question... let me see if I understand your question. You're saying what kind of tile system are we putting on the other spacecraft?

MS. HENCHLEY: Right.

MR. COHEN: Well, that is a good question. First of all, let me take the one I talked about, the OV99 vehicle. That tile system will be -- to use terminology LI-900 and LI-2200. What we will do with those... so that's basically the same material we are using on the 102 vehicle. However, all the tiles will be... are priority sonic tested to the exact strength of the tile. They will all be densified and they will all be proof-tested. So they will be... in other words, they will be basically the same material, but our priority done with the same procedures and techniques and processes that I said we had through our development stage for 102.

MS. HENCHLEY: That's something you afford to do at this time? Be applying all these tiles to the other spacecraft?

MR. COHEN: Yes. Yes, we think the tile is a very good system. Now are you saying... are there improvements we can do and sure, there are improvements we can do, and we do have improvements under study right at the moment. But the question is like anything, when is the time to really stop and put an improvement on. And we are making improvements. We are... there are things we can do to make the tiles stronger. However, when you make the tiles stronger you also change its thermal conductivity. When you change its thermal conductivity, then you change the honorable line of the tile. So every change you make, you've got to be very careful of embarking on something that is different, even though it may be a very small difference, it does have a subtle thing that you're not 100 percent sure of. So we want to be sure before we change from something that we now feel we understand to something we may be... on the surface look better, but really may not be.

MR. GORDON: Jim Maloney. Up here. Let's go with Mr. Bergman, here.

MR. BERGMAN: Air Force Secretary Mark, as you may have read, I'm sure you know him from Ames Research Center, in a speech the other week, was somewhat critical of NASA management of the Space Shuttle. And there are repeated stories from Washington that but for the military needs for the Shuttle, reconaissance and space warfare systems, that Congress might have cut the Space Shuttle budget off. How do you defend NASA management of the Shuttle and how far behind it fell?

MR. COHEN: Well, I can't... first of all I can't respond to what Secretary Mark said because I really don't know. As far as falling behind in the schedule, I think you have to set the stage that the original program was laid out, you might say, as a program that had schedule as a variable. And it was laid out as everybody knew, that it had the schedule as the variable with the fixed funding. And that's how the original program was laid out and I guess I really think that the management of NASA, the management has done outstanding job and, of course, that's my point of view, an outstanding job in maintaining and designing a very complicated system which I think has -- as I tried to point out -- and I guess the proof of the pudding is yet to come, has a great deal of applications and to solve from space man's problems on Earth. And I really think... I really feel that and I think they've done a very good job.

MR. BERGMAN: NASA's been talking about more than 50 flights a year over the next decade. Do you really believe you launch more than one Orbiter a week?

MR. COHEN: As far as the mission manifest, I'm really... I would like somebody else to answer that for you. My job is really to get the Orbiter built and I can't really talk about the mission manifest expertly and I'd rather not... I just don't feel its my field to do that.

MR. GORDON: Let's go back to Mr. Maloney over here please.

MR. MALONEY: Aaron, how did you get so far down the line before realizing the tiles would be a problem and cause all the delays they have. Was there not enough testing? Or what is the reason for that?

MR. COHEN: Well, that... again, that's a tough one to answer. It's a... I really can't give you one answer. I can say this... that there's no question that the very early testing, the very early testing on tile strength and loads came out very sound. I guess, in other words, we did panel testing early in the program that showed we had good strength in the tiles. I guess the subtlety was the non-uniformity which you'd get from sample to sample which was a subtle thing that we missed. I really can't answer the question very firmly that says that if we would have done some things earlier maybe we'd have understood more. I really don't know. The problem is... the point I was really trying to make is that the tile system is a very complicated system. It was something that was a highly efficient, reusable system, although I've been challenged on that, it was a high efficient reusable system in terms of very low density, reusable, and it's just a very... it was really pressing the state-of-the-art. And the other thing that cannot be neglected is the complications in actually determining the loads. I tried to make that point. The loads analysis and the structure analysis that goes into it is extremely complicated. We've got the best... we have had and have now the best brains you can find in the country from the research centers... all the research centers... consultants, working on understanding how you calculate aeroshock loads, how you combine these loads. It's a very tough process to understand.

MR. GORDON: One more question here and then we're going to switch to Washington.

MR. BERGMAN: Mr. Cohen, would it not have been worthwhile to have flown an unmanned Orbiter flight stripped down version

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without the computers, without the expensive avionics, but to verify the airframe and heat tile system?

MR. COHEN: Well, of course as you know, this was debated very early in the program. There was pros and cons in doing that and I don't honestly know all the details that went into that. I do know though, that it was reviewed very thoroughly at a very high level by people for and by people against it, and as many things are, the decision when all the facts were put together, it came out that the best thing to do was not to do an unmanned flight. So that's about how I can answer that question. It was not an oversight. It was a very well thought out system, thought out process of what to do. So it was very well reviewed at all levels of NASA management.

MR. GORDON: Okay, we'll switch to Washington. Do we have questions there please?

MR. SEHLSTEDT: Albert Sehlstedt, Baltimore Sun. Are all the thermal and aerodynamic loads discussed in connection with the tiles, are all those encountered only on reentry or are there some during the liftoff or enroute to orbit?

MR. COHEN: Well, the point I was trying to make is... I heard your question. The point I was trying to make is that the loads vary both for ascent and entry. So they're different. You have different loads... you essentially, for example, very little loads for thermal deflection of the vehicle during ascent where as on entry your thermal deflection normally comes in later because of heat soakback or the soak through tiles. The way you combine those loads are different for different regimes of flight. The vibro acoustic... the acoustic loads are much higher in ascent than they are in entry due to the engine and the solid rocket booster. So the loads are different during the various flight regimes and in very different places in the vehicle.

MR. FAUQUEUX: Didier Fauqueux, Agence France Presse. Do you have now a more precise date for the first launch of the Shuttle?

MR. COHEN: Well, as far as the Orbiter... as far as the Orbiter is concerned, which I represent, the move from the OPF on November 23rd looks very good. I feel that from where I sit the VAB flow time, the Vertical Assembly Building flow time, looks very good and the time on the pad looks like it is comfortable to do the job in. So I think the schedule of our internal commitment of March the 10th, our external commitment of the end of March, looks very feasible.

MR. ROSSITER: Al Rossiter, UPI. Are there... what tests do you have... what load tests do you have remaining that need to be done on the Shuttle?

MR. COHEN: There are several tests left to be done on the tiles. One is... we have test programs in about three different areas and I'll explain that to you. The first one is a... we have a flight test program at the Dryden Flight Research Center and we have a couple more flights left on tile configurations at Dryden Flight Research Center, which should be finished -- and they represent various areas of the vehicle, the window post area, the... I believe there's one on the vertical tail area that we put typical type in installations on an aircraft and fly it. We've got those tests left to do and they should be completed around the end of November. Then we have several additional vibro acoustic test articles which represent the body flap area and the vertical tail area which are here at the Johnson Space Center, that we put in our vibro acoustic test chamber and we basically vibrate those to loads you would see during... primarily during ascent. And then we have what we call combined loads orbital test article, CLOT is the word we use, that is being done at the Langley Research Center and those tests are scheduled for... one is scheduled for late December and one for the middle of January. Those are what we call combined loads tests. We basically condition the tiles, the materials and we go through various combined loads. And those are the three... those are really, you might say, the three segments of tests left to go. There are a few thermal tests but really more for verification rather than qualification.

MR. BENEDICT: Howard Benedict, AP. How soon after you get into the VAB will you mate with the boosters and with the External Tank... how long will those processes take?

MR. COHEN: I don't have that schedule in front of me, but I believe that's fairly... I think it's almost immediately. I don't recall that schedule. I think it was on one of those charts but, as I recall, I don't have the schedule in front of me, I think it's immediately. I don't know anything that detains us from doing that. It's as soon as... I think it's really limited by the... just by the mechanical movement. I don't see any... there's no other constraints that cause you not to go ahead and mate. I have that some place.

MR. GORDON: I think the Cape can respond to that one. Anymore questions from Washington?

MR. O'TOOLE: Yeah, one more. Tom O'Toole, Washington Post. You have 1,286 tiles to go, Aaron. What's the rate of putting those tiles on before you get out of the OPF and...

MR. COHEN: Well, we...

MR. O'TOOLE: Wait a minute, wait a minute. When you get into the VAB what's shift schedule you have to maintain, how many days a week to get to the pad when you want to get to the pad?

MR. COHEN: The shift schedule at the VAB the Cape will have to answer. I don't know what shifts they're on. I honestly don't know... the Cape will have to respond to that. I can't respond to their schedule.

MR. GORDON: Washington, if that's all from there we can switch to the Cape and maybe they can respond to Tom O'Toole's question.

VOICE: Yeah, get the answer from the Cape if you can, please. Thank you.

MR. HARRIS: This is Kennedy Space Center. We have several questions here. In the meantime we're trying to look up the answer to your questions there. Dick Lewis, freelance, asks: "What progress, if any, has been made in developing an alternate TPS?"

MR. COHEN: Well, let me go through several phases of the alternate TPS. There are several things that we are looking at to answer the question a little bit more specifically than I did before. If you're talking about an alternate thermal protection system basically of the ceramic vintage, which is you might say, an alternate TPS system, we are looking at a material that is called fibrous reinforced ceramic, FRCI, which has quite a bit more strength than the LI-900. FRCI-12, I'll use FRCI not to go through the name again, fiberous reinforced ceramic, FRCI-12 compares to LI-2200. Now that material develops quite a bit more strength than the LI-900, however, the FRCI-12 is a very good replacement for the LI-2200. You save weight and you get a lot more strengh, and the thermal conductivity is comparable. The FRCI-8, the problem with that, is its thermal conductivity which is the bulk of the tiles, the LI-900, it would be replaced for the LI-900, the problem with that is the FRCI-8 has the wrong thermal conductivity. So we no longer have FRCI-8. We really have to go to something like FRCI-10, which then becomes a heavier tile. So we're looking at that and we're trying to come up with a process that will allow us to go to the so-called FRCI material. So that is one thing that's under quite a bit of analysis and tests and Rockwell and at Lockheed and at the Ames Research Center. FRCI-12 looks very feasible to get some of that... some material like that on OV-99. I should have said that when the previous question was asked. However, there are other alternate materials now such as the Langley Research Center is looking at, which I am really not familiar with. Is there an alternate thermal protection system and I'm really not familiar enough to discuss that subject.

MR. HARRIS: One other question from Dick Lewis. "Is there any plan to retrieve a payload from geostationary orbit? If so, how would it be done?"

MR. COHEN: Sorry, I can't... I'm not familiar with that. You'll have to get somebody else to answer that.

MR. GORDON: We don't plan to go to geo with the Orbiter.

MR. HARRIS: We know that, Bob. The schedule for the mate of the Orbiter with the External Tank shows that it goes on from the 23rd to through the 28th with the Shuttle powered up about the 27th, so it doesn't say exactly how many hours after we move into the VAB before it actually is hoisted, but it looks like within a day from this chart.

MR. GORDON: Hugh Harris?

MR. HARRIS: Yes, go ahead, Bob.

MR. GORDON: I think the second part of that question are you working around the clock?

MR. HARRIS: Yes. We're working around the clock on all of the other elements at the present time so I think we'll be working around the clock on that also.

MR. GORDON: Anymore from KSC?

MR. HARRIS: Yes. We have one from Dan Fiorucci.

MR. FIORUCCI: Okay, the first question, last week officials in Huntsville announced that the main engines would no longer be a factor in delaying the launch beyond March, that barring anything unforseen? Can the same be said of the thermal protection system at this point?

MR. COHEN: Yes. I feel it can be. We do have, as I pointed out, several tests to go. I feel very confident with those tests so I feel right now that the thermal protection system will not be a constraint to the March flight date.

MR. FIORUCCI: One or two more questions. How many tiles have been put on the vehicle total -- 30,000, of course, the total number on it at any one given time -- but with all the ones that you've peeled off and put back on since it was in Palmdale.

MR. COHEN: If I would give you an answer it would be a guess because I really don't know... I mean I just don't know off hand. I can get the exact number. I know there's no question... we have taken, as I pointed out, we have taken a number of tiles off because of the loads that I described, we have taken a number of tiles off because they have failed the proof test that I described, and we've taken a number of tiles off because we decided to densify the tiles. So there's no question we have taken tiles off for those reasons. I think they were valid reasons and they were complications that we had to resolve and the exact number, I just honestly don't know.

MR. FIORUCCI: In rough terms could it be said that it would have been enough to tile the vehicle two or three times over? Is that close to accurate?

MR. COHEN: I don't think two or three times, or three times. It might be that we put on more than half as many again, but I really can't say if it's been twice as many. I really don't know the answer.

MR. FIORUCCI: Okay, and the final question, is $700 million the approximate cost of the two-year delay in launch?

MR. COHEN: I can't respond to where you got your numbers. I really don't know... can't respond to that.

MR. HARRIS: We've checked the time for the hard mate of the Orbiter to the External Tank and hard mate will occur two days after it moves into VAB. That's all the questions from KSC, Bob.

MR. GORDON: Okay, thank you, Hugh. We'll go to Marshall?

MR. DOOLING: Dave Dooling, the Huntsville Times. Mr. Cohen, on the new tiles... on the tiles that will be going on to the Columbia between OFT missions, will those be the new LI-900 and 2200 tiles, and how soon do you expect that the rate of replacement will come down to something more manageable like maybe 50 to 100 between missions?

MR. COHEN: First of all, the tiles that we would replace between flights will really be LI-900 or LI-2200 sonic, so-called sonic tested, and densified tiles. Those will be the type of tiles that will be put on between flights. As far as when we will come down to a lower number of tiles between flights, again that's a very tough one to answer until we actually fly. So I really don't know. I would say that we will have some, you know just to be honest, we will have some repair between flights, some tile replacement between flights. The point being though, changing out X number of tiles between flights will not be a constraint to the turn-around time, so I don't think whether you talk about 50 tiles between flights or several hundred tiles between flights, you're really going to affect the operational use or the turn-around time of the vehicle.

MR. DOOLING: One more on the total payload bit, Columbia and the follow-on Orbiters will be able to carry. I understand that Columbia is overweight even with lightweight tank and booster will still fall short of the 65,000-pound design goal. How short and what will be the payload on Challenger and Discovery and Atlantis?

MR. COHEN: As far as the payload that the... that 102 will be able to handle, yes we are short of the 65,000 pounds. I'm not quite sure how much, I think it could be up to several thousand pounds. However, we do have still in the process, things to get performance back on the vehicle. The problem is, it would take... it would make... say you'd have to take the vehicle out of the fleet for some time. So I think eventually we'll be able to recover some of the weight... of the capability back. So I

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think eventually we'll be able to do that. Now just when that is, I don't know, but we are looking at that and when we'll be able to do it. As far as the follow-on vehicles, we have a weight reduction program that we're in and that looks pretty promising and I... right now the follow-on vehicles will be very close to carrying their designed requirements.

VOICE: That's all from Huntsville. Thank you.

MR. GORDON: Okay, we have some more from Houston?

VOICE: Yes. Where would you put the difficulty and complexity in STS as compared to the Apollo project?

MR. COHEN: That's a very good question. If you remember, I may be overstating a little bit, but not too much. Let me... if you go back to... if you got a copy of the handout... if you look at... on chart 8, which shows a picture of the orbital maneuvering system pod, other than the fuel cells that we had in Apollo in the service module, that's basically equivalent to the service module. You might say that's like the service module in Apollo... that the orbital maneuvering system pod, the only thing different in this pod really than the service module in Apollo, which goes right here on the Orbiter, is really fuel cells and, of course, cryo tanks. Now there's complexity but it is a little bit... I mean... I mean that doesn't give you the whole thing, but that is almost... that's typical of it. Of course Apollo didn't have also the aerodynamic considerations of a winged vehicle, but that is one way you might explain the complexity of the vehicle over and above Apollo.

VOICE: Well this seems to be pushing the state-of-the-art so much that its causing delays as the technology is actually developed and, of course, the Apollo project was really, really pushing the state-of-the-art. At the beginning I doubt that anybody in the lay public believed that it could really be done by the deadline. Yet, it was and now, you know, we have all that experience and it seems kind of frustrating that the STS is not going yet. Is it because of unforeseen difficulties?

MR. COHEN: No, I think I called out to your... how complicated the vehicle is. I think I called your attention to the three areas. I think the people at Marshall have done an outstanding job on the state-of-the-art of the main engine. I think the avionics system was a state-of-the-art and the thermal protection system. So I really think those are only the three places where we really pushed the state-of-the-art. As far as... as far as Apollo was concerned, I think you have to say the Apollo mission probably was pressing the state-of-the-art... at least the way I look at it. Everybody may not agree with me. I think the Apollo mission was pressing the state-of-the-art. The vehicle wasn't probably as complicated as this. Here we're probably not pressing the state-of-the-art on the mission as much as we are... it is a complicated vehicle. So the mission was, you might say, on Apollo was pretty unforgiving in terms of what we had to do.

MR. GORDON: Louie Alexander, Newsweek, right here in the red shirt.

MR. ALEXANDER: Would you estimate the cost of the Orbiter so far and the cost of Orbiter up to the moment of launch?

MR. COHEN: Well let's see. You mean the cost of the program?

MR. ALEXANDER: Uh, huh.

MR. COHEN: The cost of the program... in the DDT&E program, at the time, is approximately $4 billion... is the cost of the DDT&E program.

MR. ALEXANDER: Per Orbiter?

MR. COHEN: On the Orbiter program, approximately $4 billion. This is real year dollars.

MR. GORDON: Right here, ABC.

MS. ABRAMS: Stephanie Abrams, ABC News. The improvements he's mentioned regarding the tiles, are you talking about a totally new thermal protection system and, if so, how much would that cost?

MR. COHEN: Well, that what... let me try it again. There's two things in the thermal protection system I tried to distinguish. When I talk about phasing in a new ceramic material, staying with the basic ceramic material, that's what I'd call an alternate system. That is being looked at and probably will be phased in. I would say... I would say for 103 and 104, we probably will have the so-called FRCI. All right? Which will be stronger, it will... it will be a little bit more forgiving. All right? However, if you talk about new thing, that is not... that is... I can't estimate the cost but that's not very significant in terms of cost. If you're talking a new thermal protection system, which is a new concept, which is either a metallic system, I really couldn't estimate that cost. That would be very large. And I'd like... I don't think I've given a very good answer. Let me try once more. OV-99, the question was asked, what are we doing on OV-99, and I told you. I said it's basically the same system. For 103 and 104, we do feel that we will be able to get FRCI material on 103 and 104. That's what I just... I wanted to elaborate that issue, that it was understood.

MR. GORDON: Jules Bergman.

MR. BERGMAN: Aaron, one thing nobody's talked about so far, it seems to me, is safety, crew safety. Apollo, as you remember and I remember, we had an escape tower that was reasonably infallible, never had to be used, but it worked beautifully as we knew from numerous tests. Here we have ejection seats, and one of the stories going around is the ejection seats don't even escape the flame pattern if the Shuttle goes up on the pad. Are you happy with crew safety?

MR. COHEN: Yes, I am. The ejection seat, of course that's... we again, its very similar to the previous review we had. You asked about the unmanned versus manned flight. The ejection seat, again, was a very well deliberated system. We decided to fly the ejection seats certainly for the approach and landing test program and for the early flight test program. Now the problem with an ejection seat... It is very difficult to design an ejection seat that meets all the regimes of flight. The fireball that you have is very tough to get around. We will have some capability for off-the-pad ejection, however, you always have those type of concerns in ejecting off the pad... when you're on the pad. During flight the ejection seat, by tests we've run at Holloman, show to have very good performance during the flight, certainly horizontal flight regime, and during certain phases of the boost regime. But off-the-pad ejection is a very tough one. Now as far as the other question about safety, the safety of the Orbiter system, of course, is designed basically in the hard-core systems fail-operational/fail-safe, as you know. By that I mean you can lose, and I showed you the computer system, you can lose one system and still continue on the mission. You can lose another system and still come back... still have another system to come back on safely. So the safety aspects of the redundancy of the Orbiter are really many-fold over that, in many regards, that we had in Apollo.

MR. BERGMAN: Let's go to the initial launch phase. You are confirming, are you not, as the crews have told me, that there are large gaps in off-the-pad safety capability... that the ejections seats might not get you clear of any blast pattern or flame pattern. And you're also saying that after flight two, the second test flight, there are no ejection seats.

MR. COHEN: I believe the ejection seats will be in for the first... will be through the flight test program.

MR. BERGMAN: So after the... after several tests of the flight test program...

MR. COHEN: The ejection seats will...

MR. BERGMAN: When the Orbiter becomes operational...

MR. COHEN: The ejection seats will come out. Yes.

MR. BERGMAN: And there's no protection. There's no escape tower or anything else.

MR. COHEN: What do you have in a DC-10?

MR. BERGMAN: I don't fly DC-10s, sir.

MR. COHEN: All right, 747s.

MR. BERGMAN: 727s don't go that way.

MR. COHEN: No, but I mean, you don't have, you know, the personal parachute system or whatever you have, it's just not feasible to do it on a... in a system.

MR. BERGMAN: I think there's a difference, Aaron, between a 727 or 1011 or airliner that takes off with a hundred people for point A to point B...

MR. COHEN: No, but the point I'm making... it's very difficult to... it's very difficult to have a... in other words, we were able to design an ejection seat... the best state-of-the-art ejection seat we could for the flight test crew. To put an ejection system in for a crew of four or a crew of seven is pretty much... you know, I don't know how you'd do it. So the system is safe, it has a lot of redundancy, it's got a lot of abort capability, and I really feel that crew safety is as good on this vehicle, or is better on this vehicle as it has been on previous vehicles.

MR. BERGMAN: Well, a man you used to work with closely, you're fond of, I'm fond of, and has infinite respect for you, called the system insane to me yesterday, quote, unquote.

MR. COHEN: I'll have to talk to him.

MR. BERGMAN: You should.

MR. GORDON: We could discuss that separately outside this room, I believe. Anymore questions from Houston? Washington? KSC? Marshall? Okay thank you ladies and gentlemen. Next briefing will be November 5 in this room with Donald K. Slayton. He will discuss the first four flights, Orbital Test Flight Program. For those of you who have signed... please sign the register so you can get the transcript. Thank you.

-end-

NASA-S-80-2296

ORBITER VEHICLE 102 FLIGHT TEST PROGRAM SCHEDULING AND MODIFICATIONS

How the Shuttle Operates

LAUNCH

SOLID ROCKET BOOSTER SEPARATION

EXTERNAL TANK SEPARATION

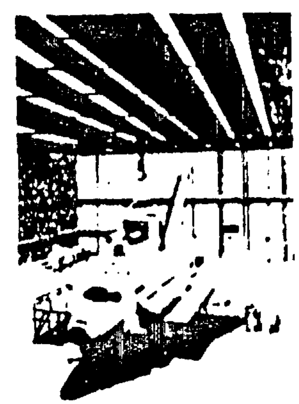
ORBITAL INSERTION

ORBITAL OPERATIONS

RETROFIRE FOR REENTRY

ATMOSPHERIC ENTRY

LANDING

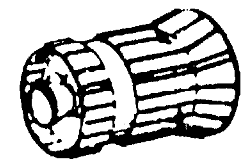


SERVICING FOR RELAUNCH

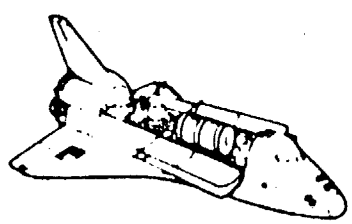
SPACE SHUTTLE ASSEMBLY

Wide Variety of Missions

SATELLITES



PROPULSION STAGES



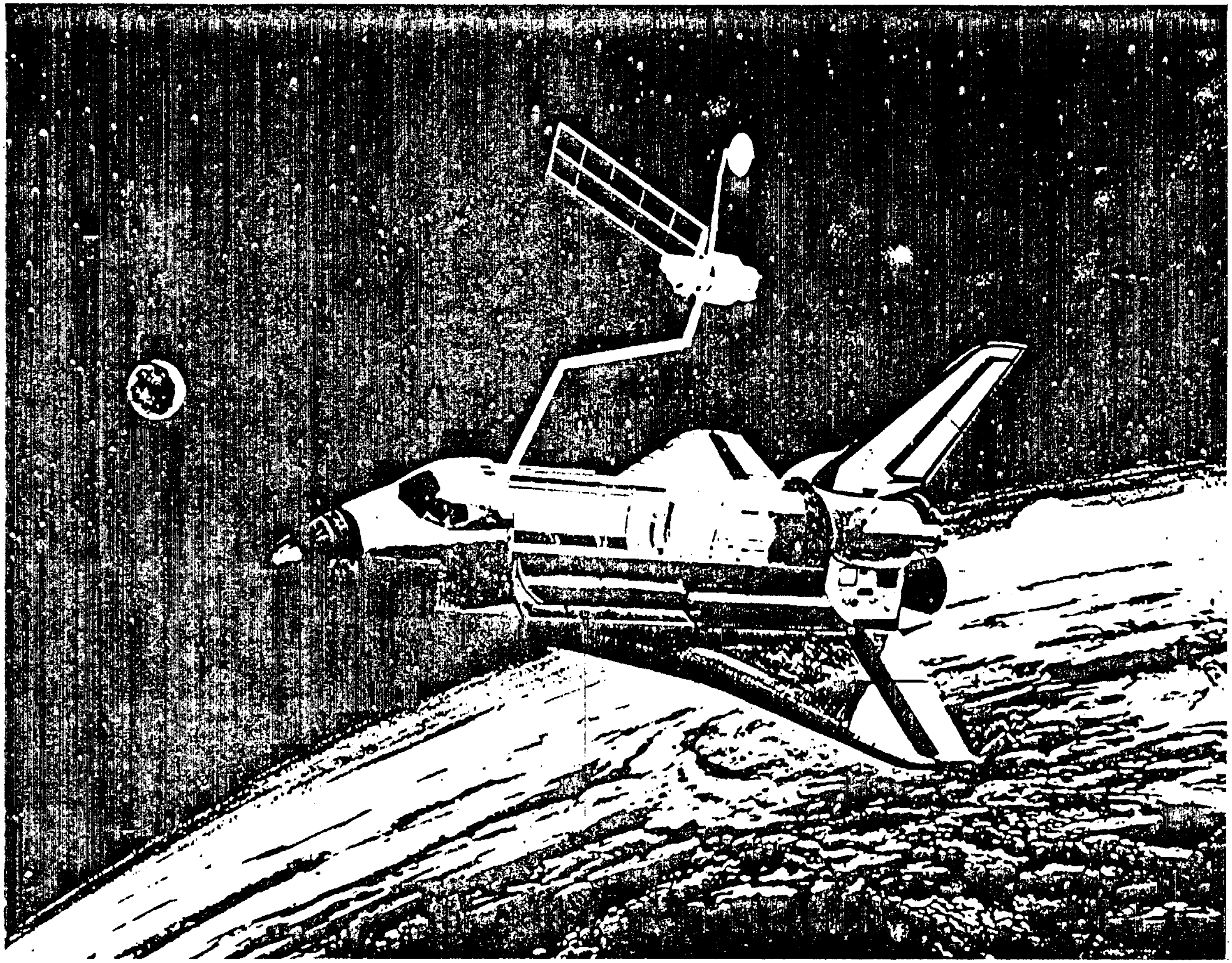
LABORATORIES

OPERATIONS

- DELIVERY & PLACEMENT IN EARTH ORBIT OF:
  - SATELLITES/SPACECRAFT
  - PROPULSION STAGES
  - OTHER PAYLOADS OR CARGO
- RETRIEVAL OF EXPENSIVE PAYLOADS FOR REUSE
- SERVICE & REFURBISHMENT OF SATELLITES IN SPACE
- TRANSPORT TO ORBIT, OPERATE, & RETURN
  - SPACE LABORATORIES
  - SHORT-DURATION PAYLOADS
- SAFE, COMFORTABLE TRANSPORT OF PASSENGERS

APPLICATIONS

- LABORATORIES FOR RESEARCH IN:
  - PHARMACOLOGY
  - MATERIALS
  - MANUFACTURING PROCESSES
  - BIOLOGICAL & LIFE SCIENCES
  - SPACE PHYSICS
  - ADVANCED TECHNOLOGY
- SCIENCE SATELLITES FOR:
  - ASTRONOMY & PHYSICS RESEARCH
  - PLANETARY EXPLORATION
- EARTH RESOURCE EXPLORATION, INVENTORY, & DEVELOPMENT IN:
  - MINERALS & FUELS
  - FARM LAND, TIMBERLAND, & RANGE LAND
  - HYDROLOGY & WATER POLLUTION
  - GEOGRAPHY, CARTOGRAPHY, & TOPOGRAPHY
  - OCEANOGRAPHY
  - LAND USE & PLANNING
- COMMUNICATIONS
- NAVIGATION
- METEOROLOGY & WEATHER
- GEODETICS
- NATIONAL SECURITY
- ERECTION OF LARGE SPACE SYSTEMS
- SPACE STATION LOGISTICS
- PAYLOADS FOR NEW OR UNFORESEEN PROBLEM SOLUTION



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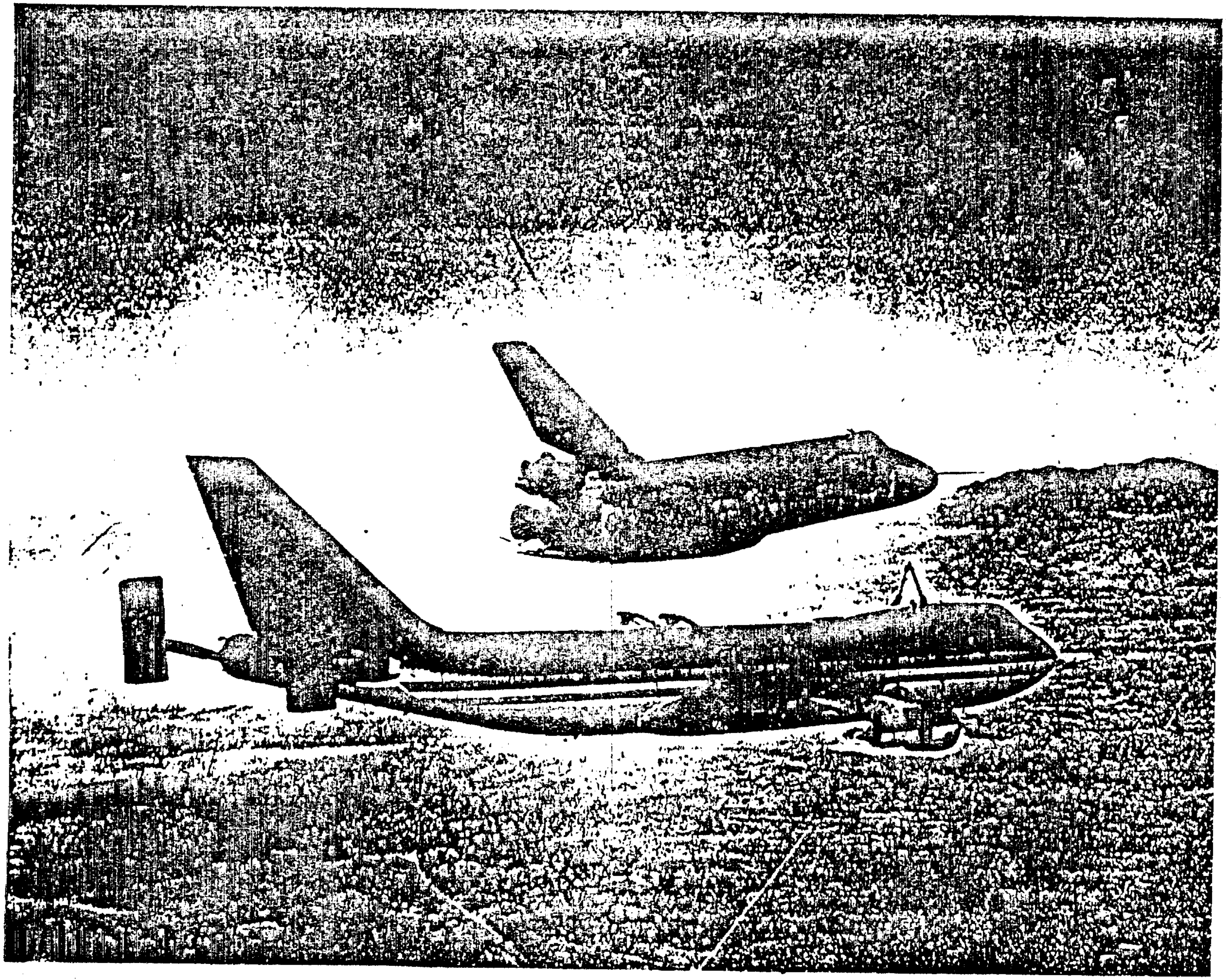

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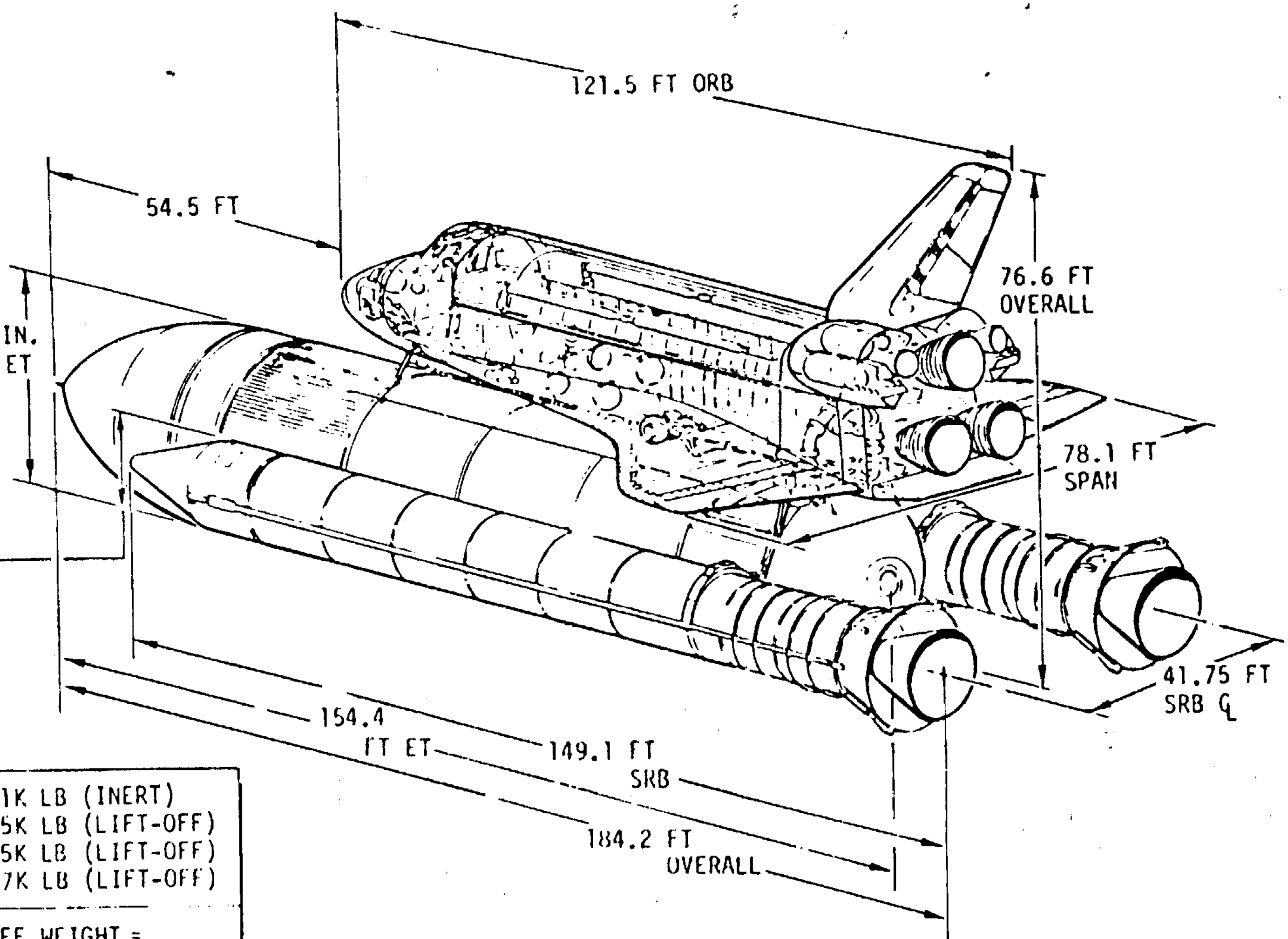
THE SPACE SHUTTLE VEHICLE

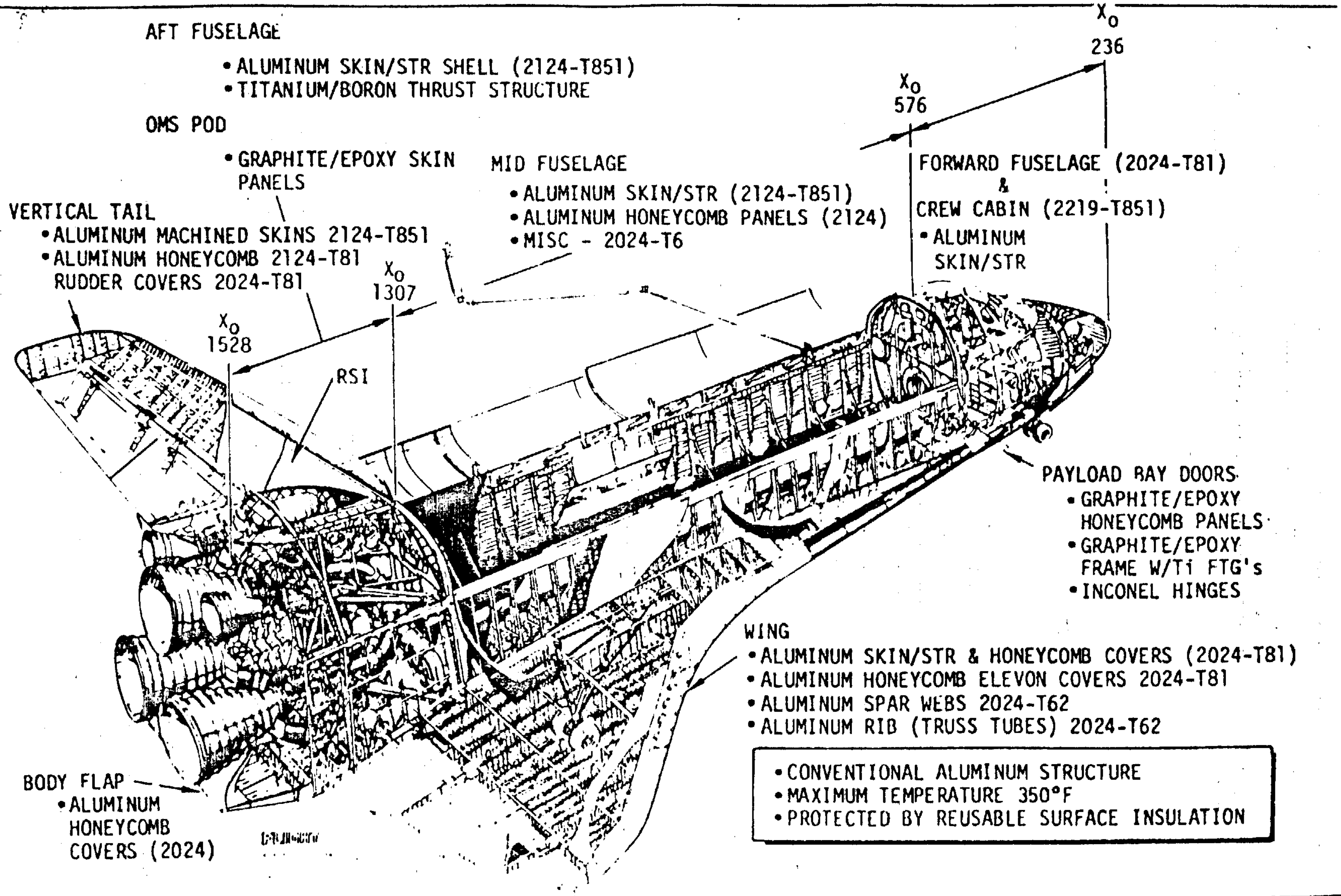


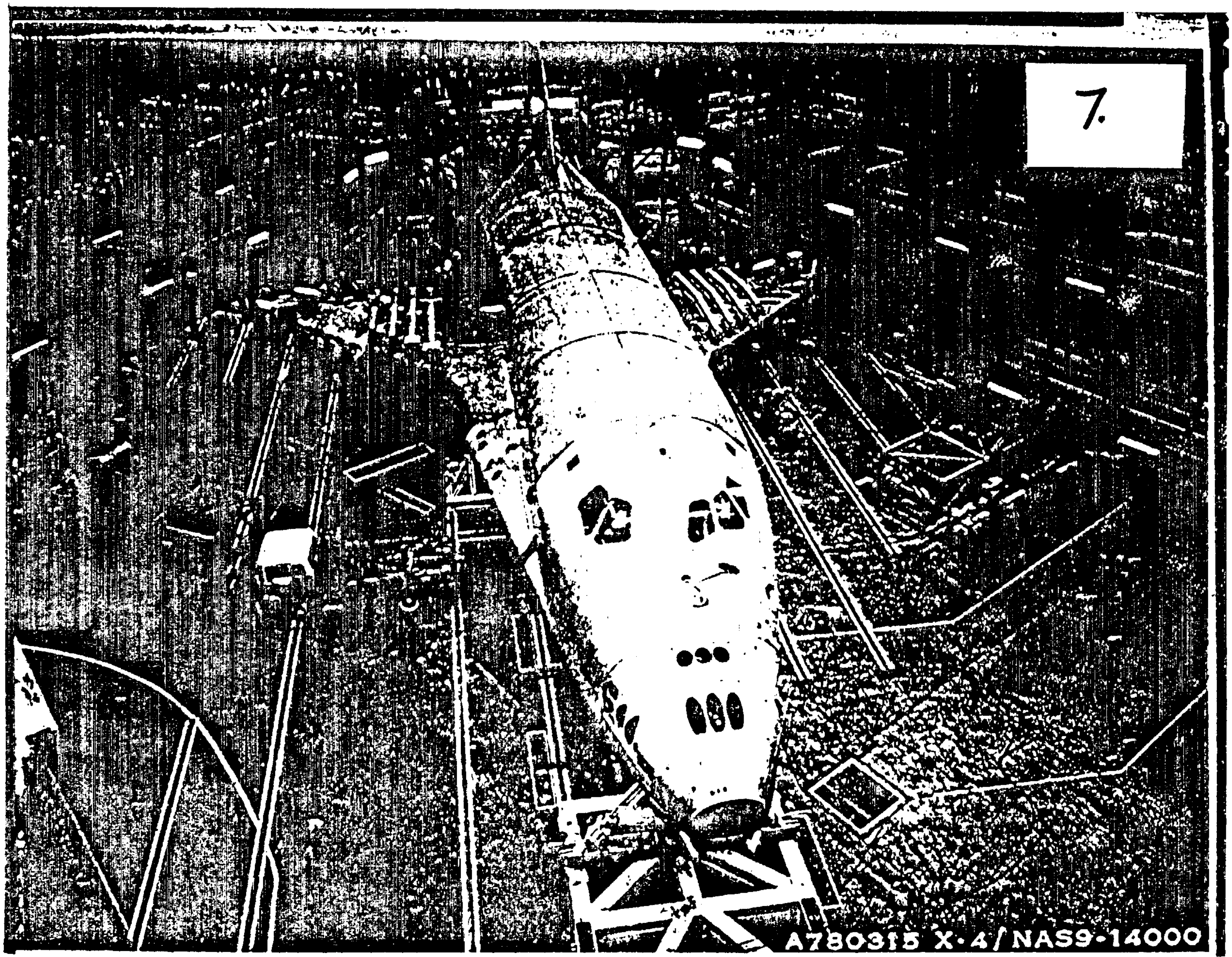
ORBITER	151K LB	(INERT)
	215K LB	(LIFT-OFF)
ET	1655K LB	(LIFT-OFF)
SRB	2587K LB	(LIFT-OFF)

GROSS LIFT-OFF WEIGHT =
4457K LB - 32K LB PAYLOAD
TO 50 X 100 NMI AT 104 DEG
INCLINATION

6

Orbiter Structure

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A780315 X-4 / NAS9-14000

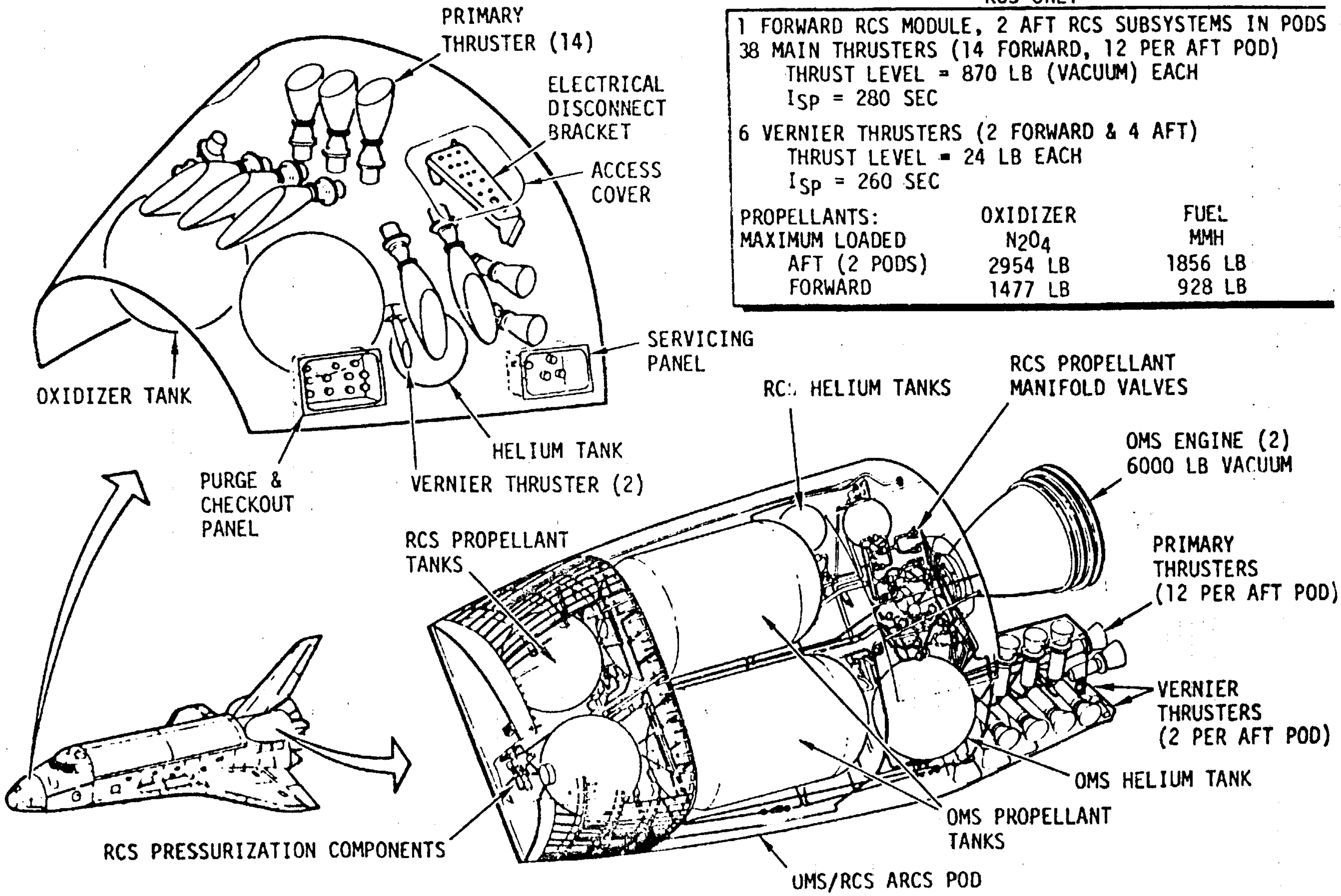
Reaction Control Subsystem

RCS ONLY

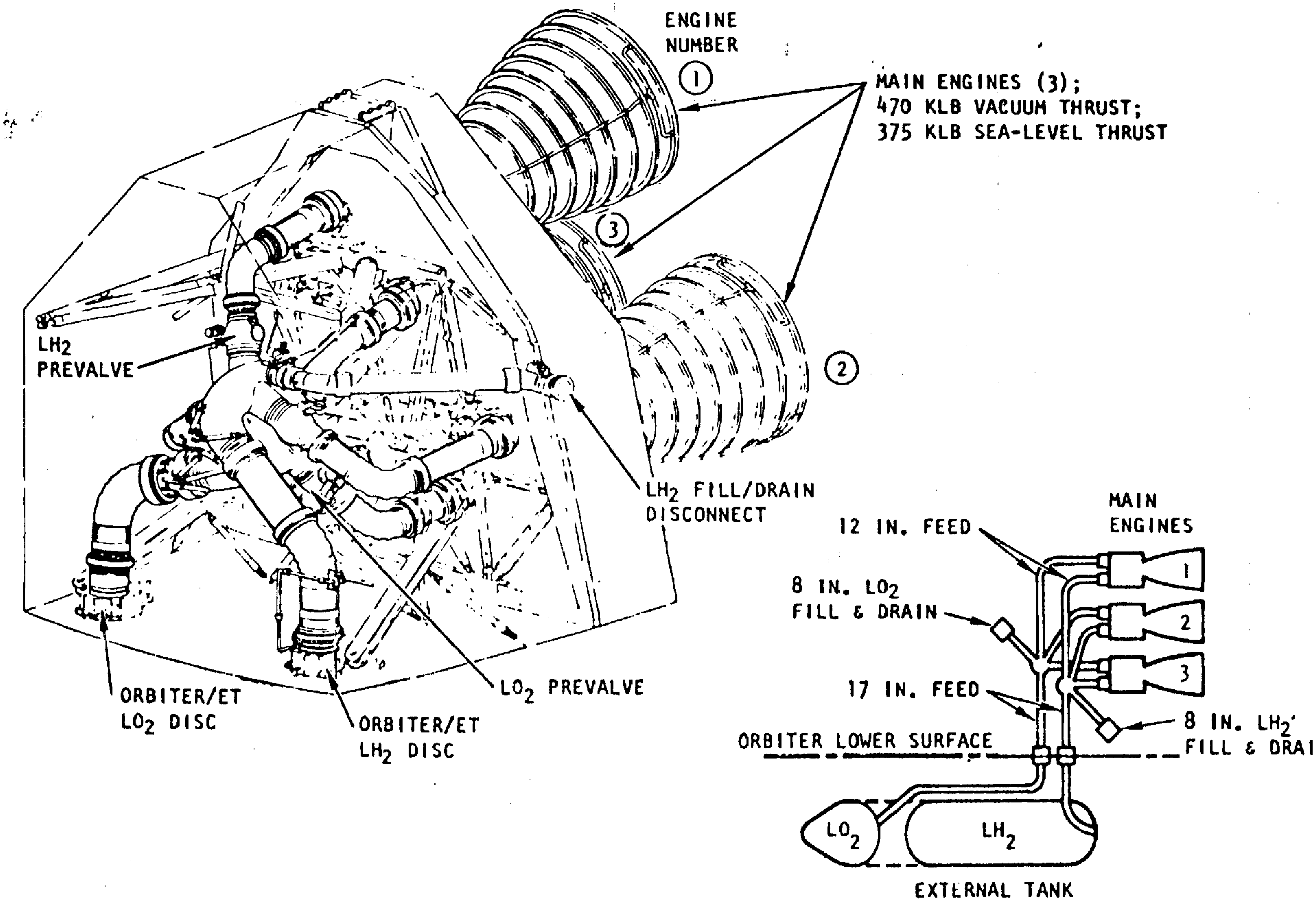
1 FORWARD RCS MODULE, 2 AFT RCS SUBSYSTEMS IN PODS
38 MAIN THRUSTERS (14 FORWARD, 12 PER AFT POD)
THRUST LEVEL = 870 LB (VACUUM) EACH
I_{SP} = 280 SEC

6 VERNIER THRUSTERS (2 FORWARD & 4 AFT)
THRUST LEVEL = 24 LB EACH
I_{SP} = 260 SEC

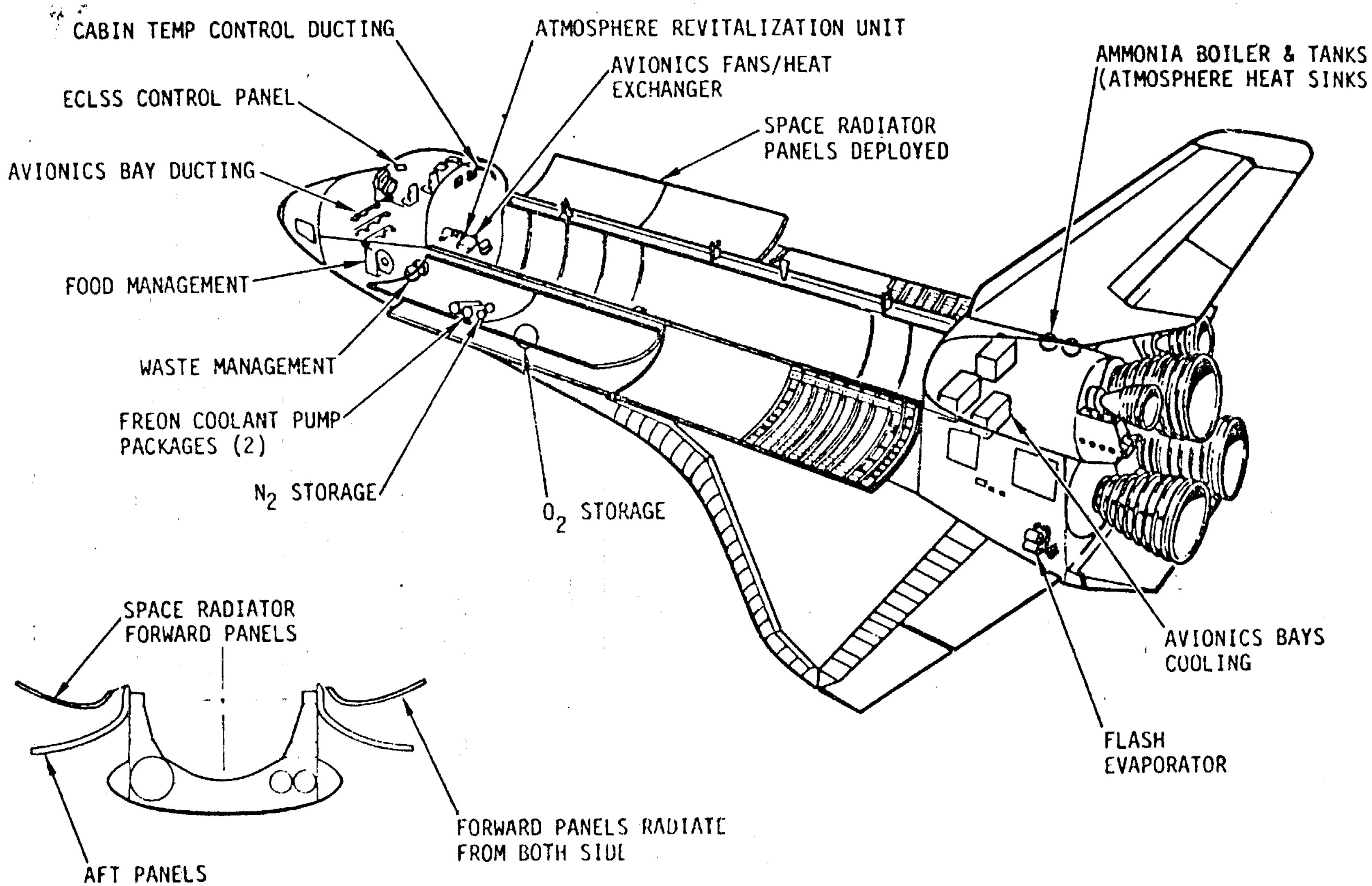
PROPELLANTS: MAXIMUM LOADED	OXIDIZER N_2O_4	FUEL MMH
AFT (2 PODS)	2954 LB	1856 LB
FORWARD	1477 LB	928 LB



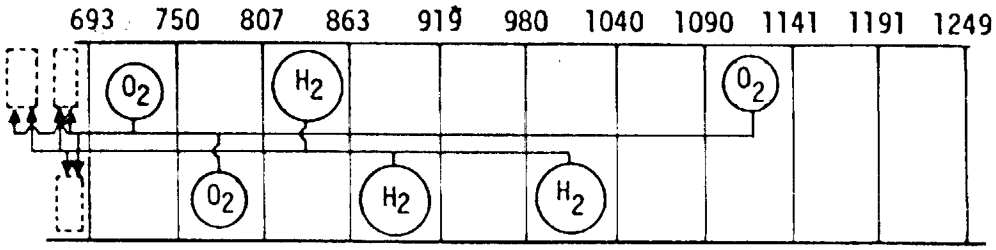
Main Propulsion Subsystem



Environmental Control and Life Support Subsystem



Electrical Power Subsystem



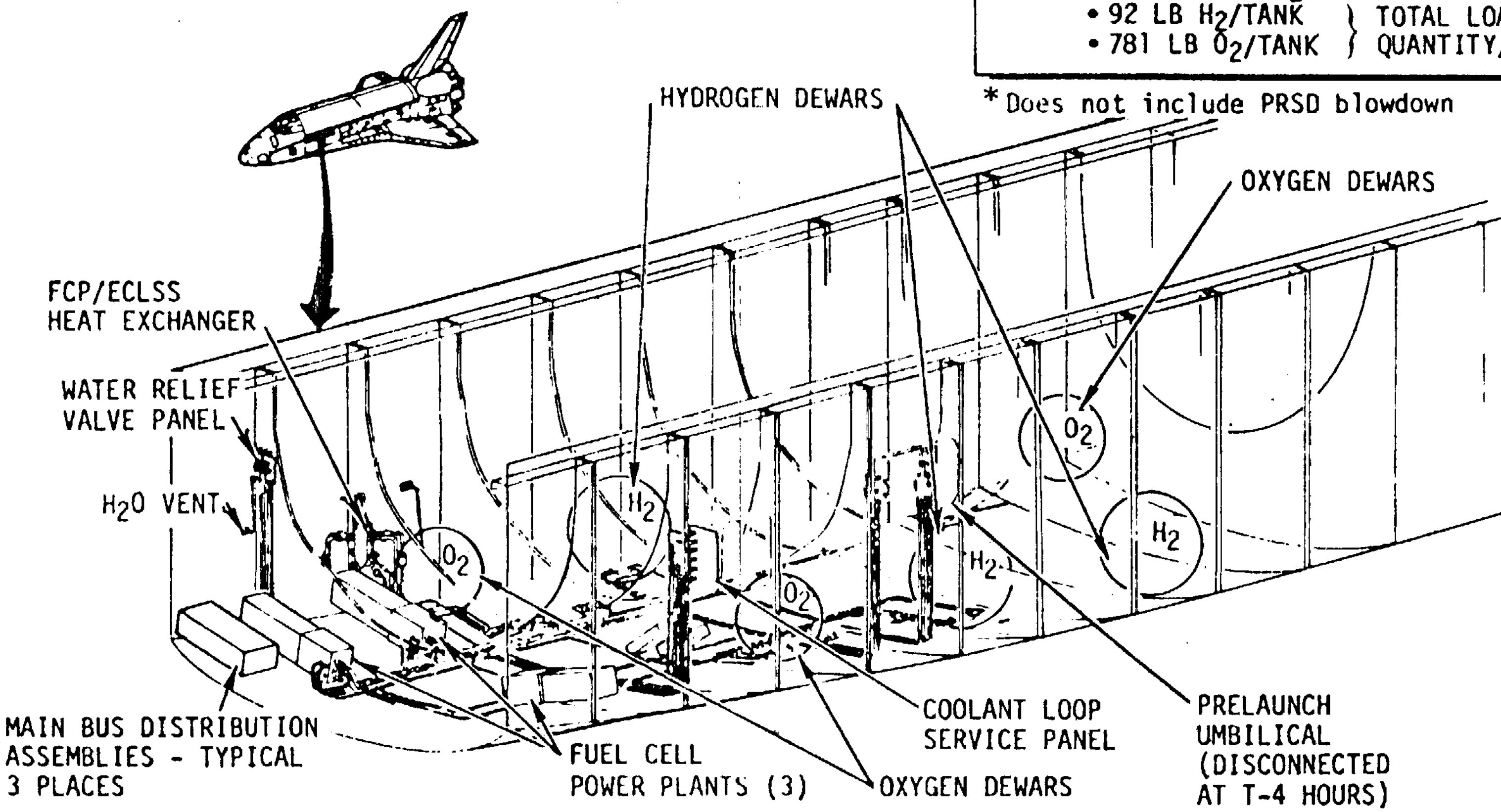
FCP SUBSYSTEM (2 FCP's)

- 14 KW CONTINUOUS/24 KW PEAK
- 27.5 TO 32.5 VDC

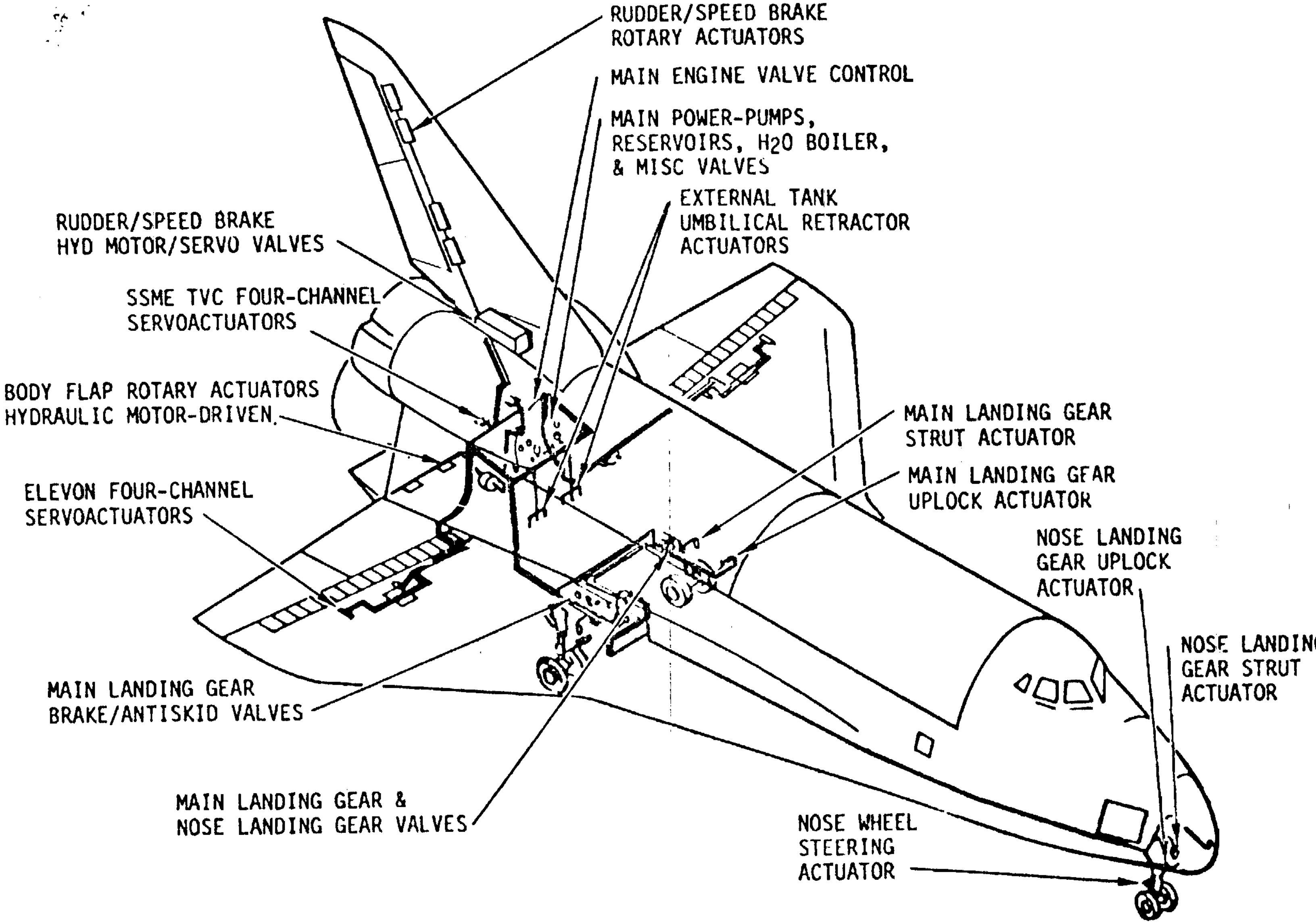
REACTANT STORAGE (3 TANK SETS)

- 2370 KWH DELIVERED ENERGY*
- 168 POUNDS O_2 FOR ECLSS
- 92 LB H_2/TANK } TOTAL LOADED
- 781 LB O_2/TANK } QUANTITY/TANK

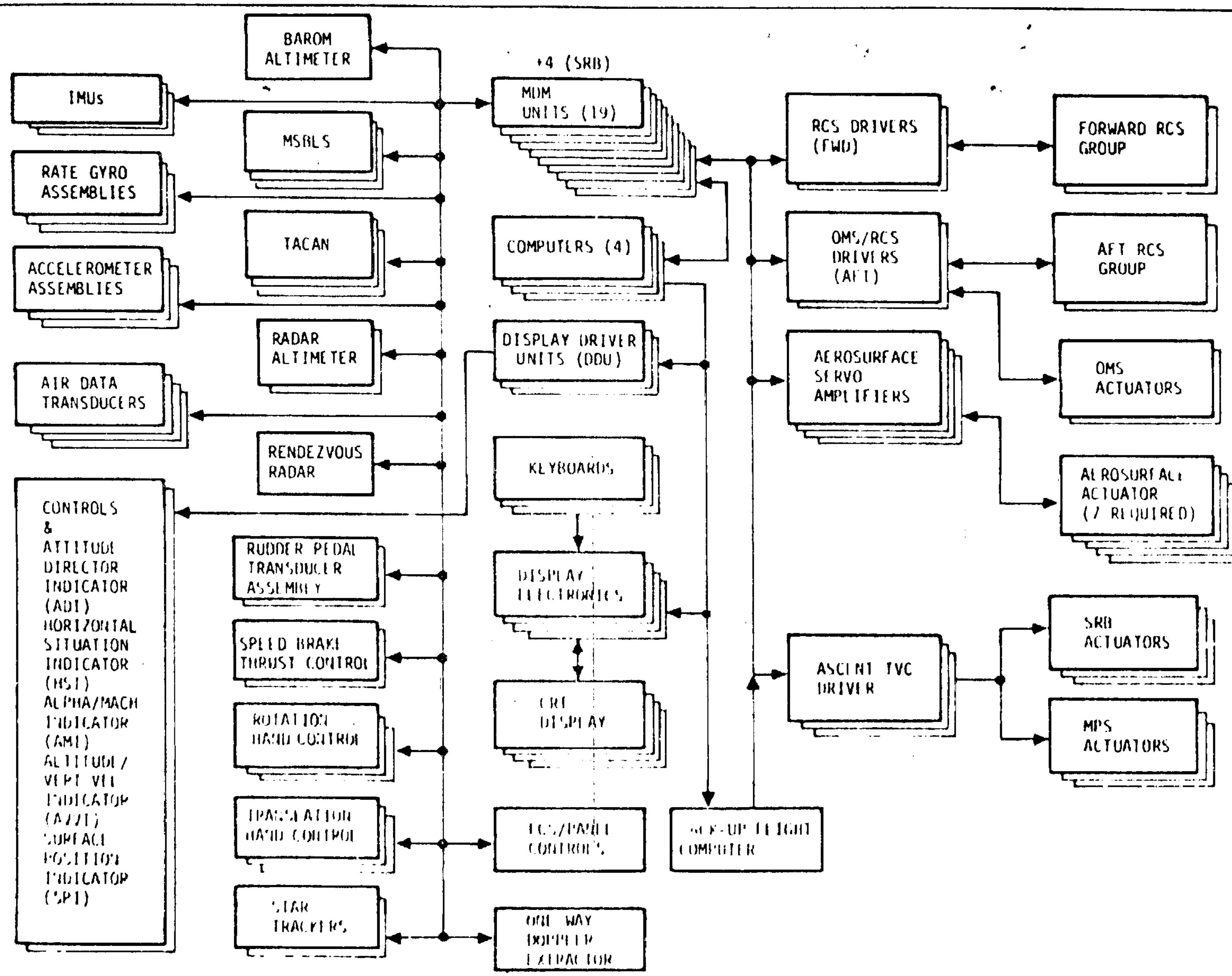
*Does not include PRSD blowdown



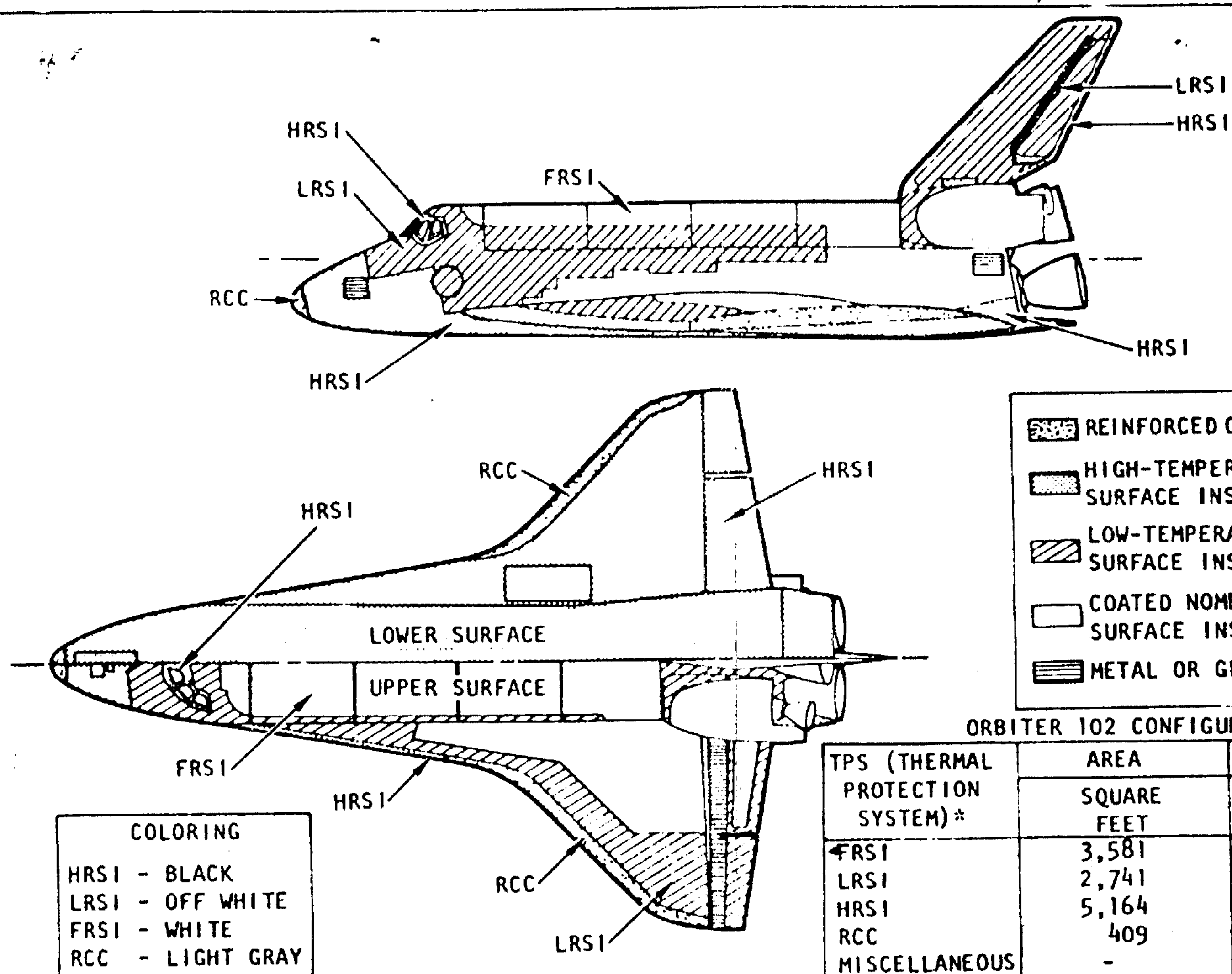
Hydraulic Subsystem



Guidance, Navigation, and Control Subsystem Functional Block Diagram



Thermal Protection Subsystem



- REINFORCED CARBON-CARBON (RCC)
- HIGH-TEMPERATURE, REUSABLE SURFACE INSULATION (HRSI)
- LOW-TEMPERATURE, REUSABLE SURFACE INSULATION (LRSI)
- COATED NOMEX FELT REUSABLE SURFACE INSULATION (FRSI)
- METAL OR GLASS

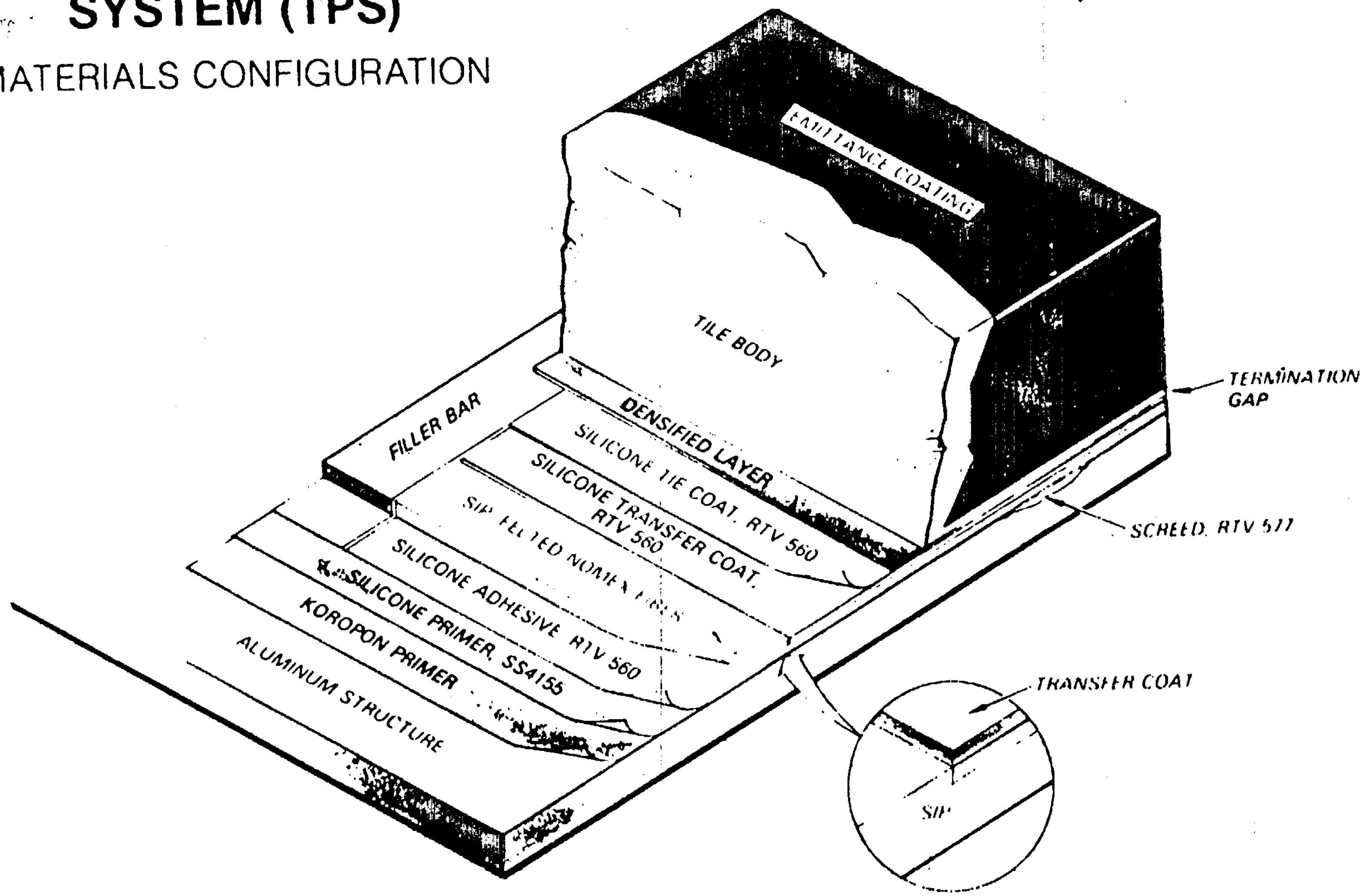
ORBITER 102 CONFIGURATION

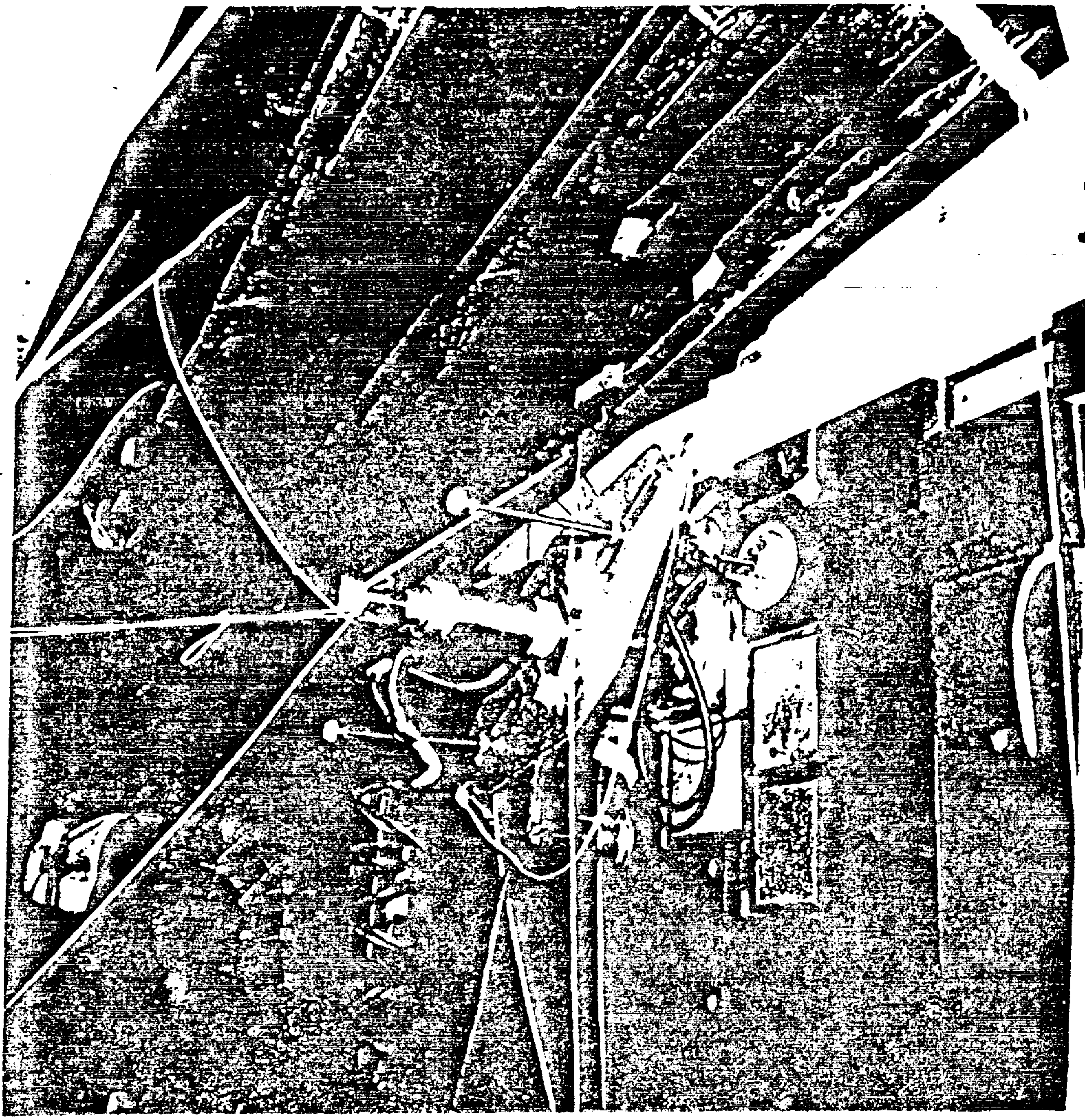
TPS (THERMAL PROTECTION SYSTEM)*	AREA SQUARE FEET	WEIGHT POUNDS
FRSI	3,581	1,173
LRSI	2,741	2,236
HRSI	5,164	9,728
RCC	409	3,742
MISCELLANEOUS	-	2,025
TOTAL	11,895	18,904

*INCLUDES BULK INSULATION, THERMAL BARRIERS, & CLOSEOUTS

THERMAL PROTECTION SYSTEM (TPS)

MATERIALS CONFIGURATION





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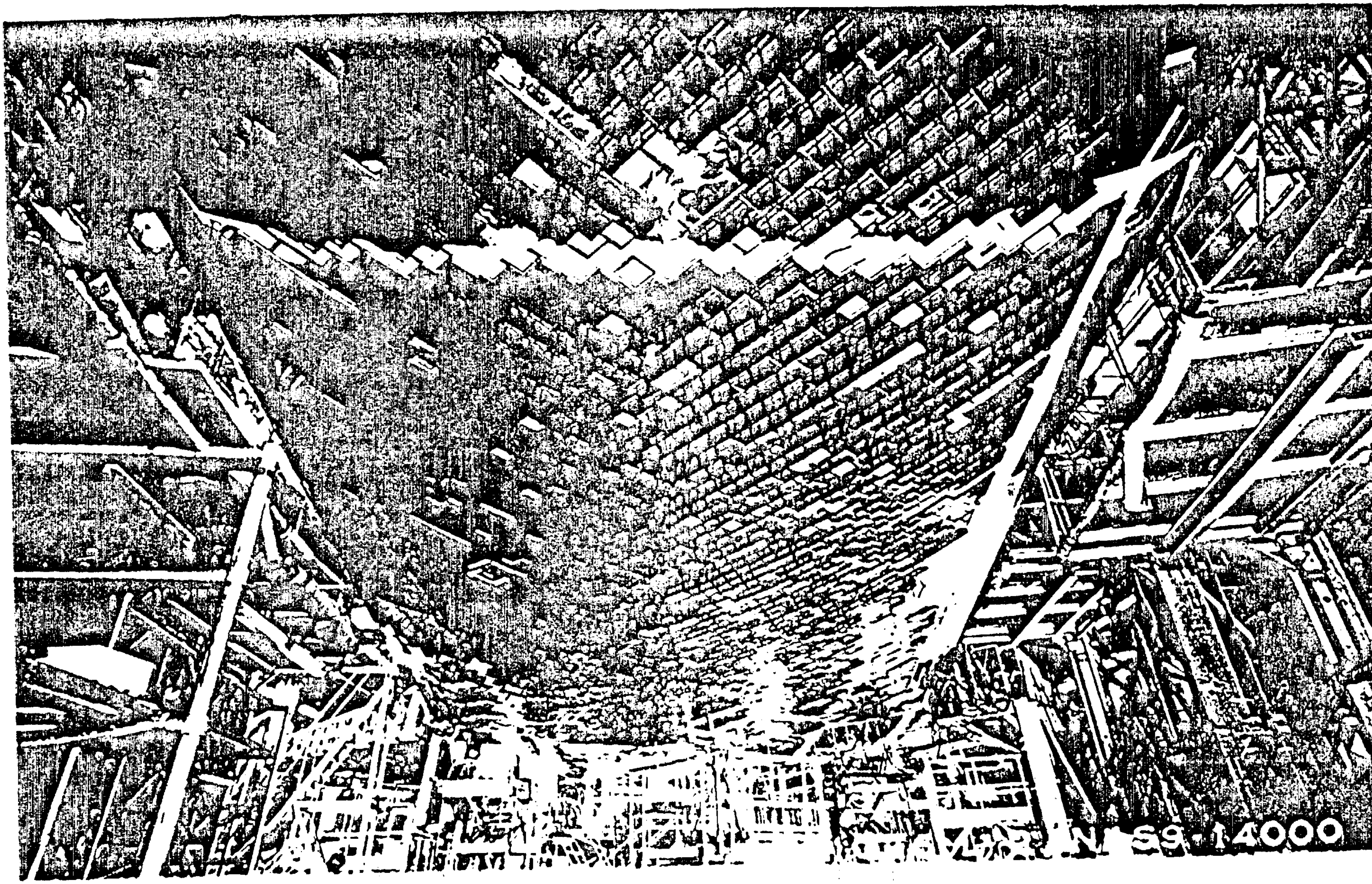

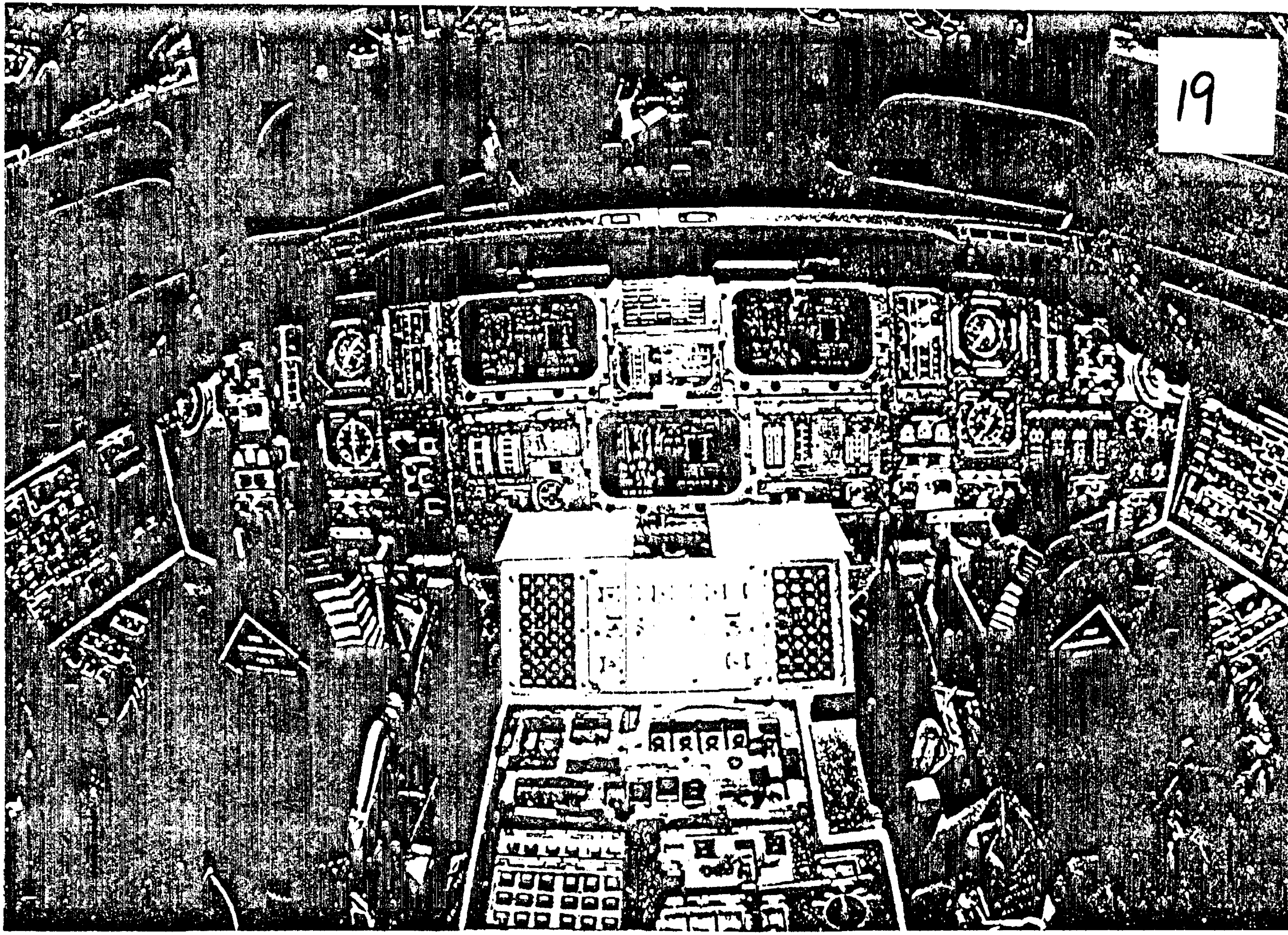
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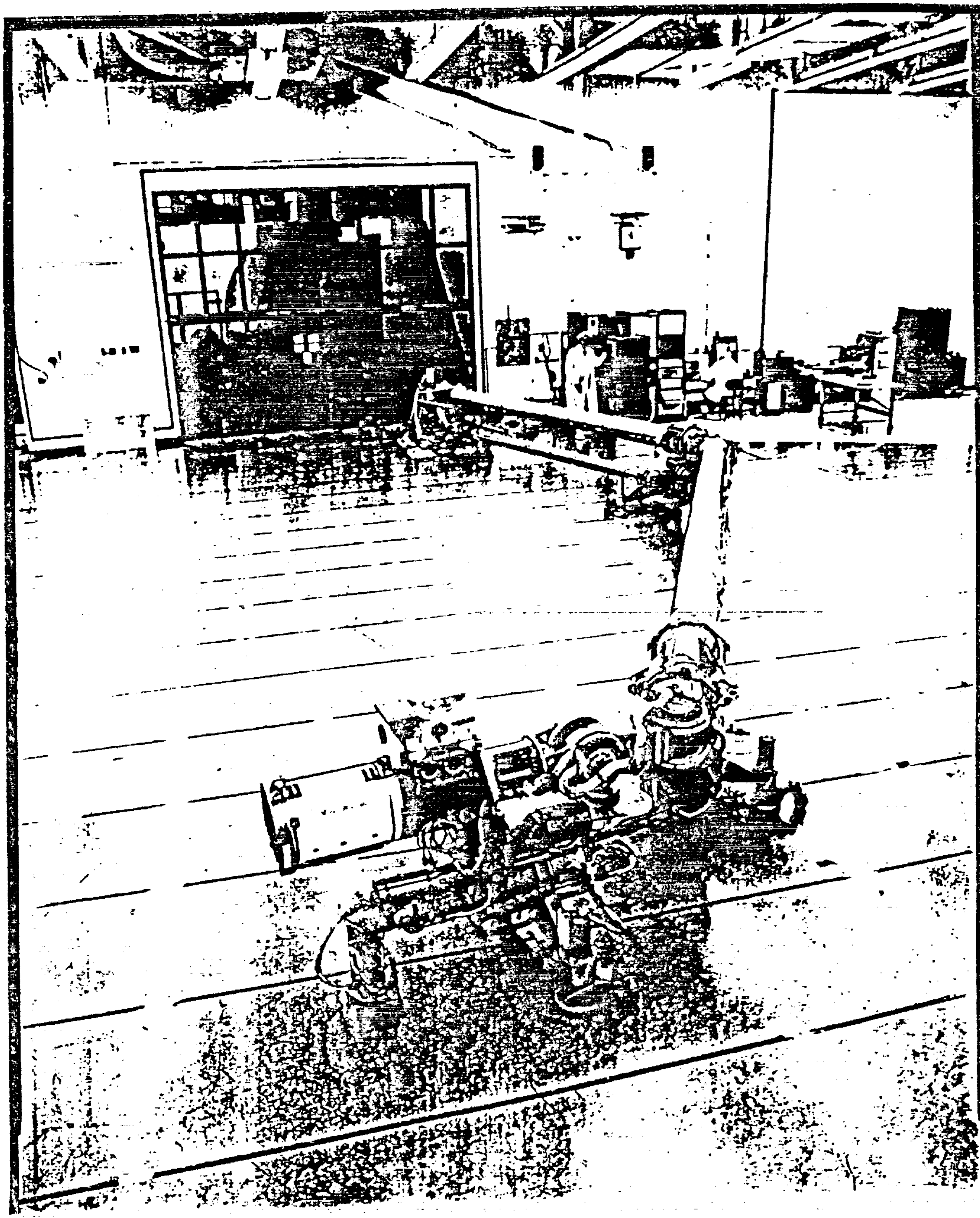

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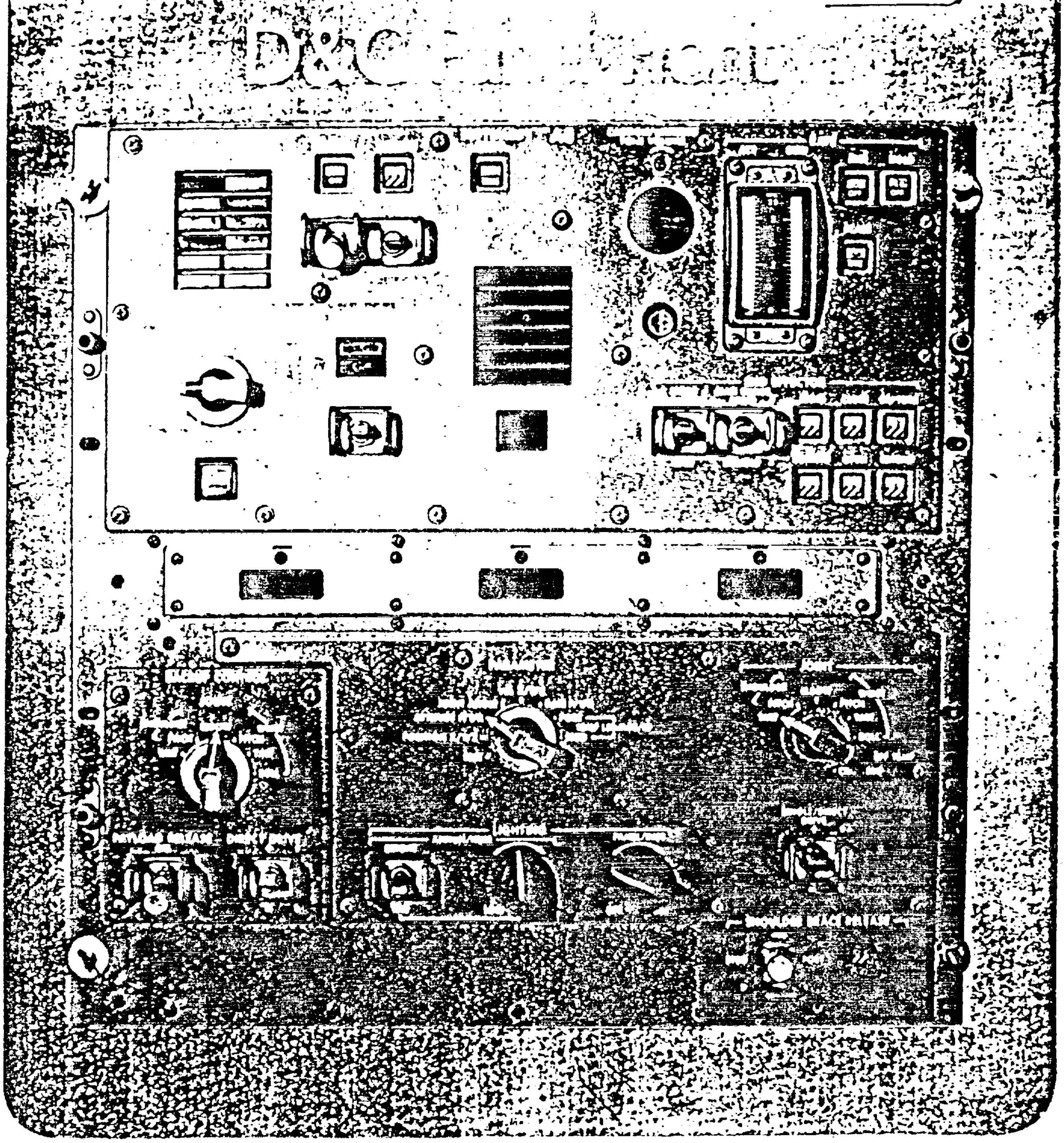
SPAR



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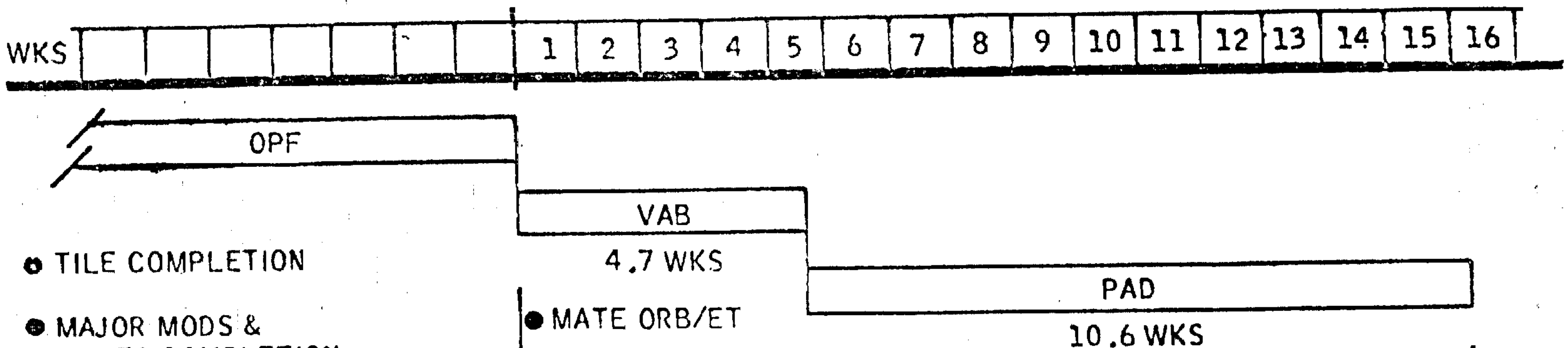
STS-1 FLOW PLAN



OPF

- TILE COMPLETION
- MAJOR MODS & MFG COMPLETION
  - OMS/RCS
  - SSME
  - 5.4 LOADS
  - APU'S
- TESTING
  - SYSTEMS TESTS
  - APU HOT FIRE
  - ORBITER INTEG TEST
  - DYNAMIC STABILITY
  - FREQUENCY RESPONSE
  - STRUCT INTEG
  - CREW EQUIPMENT I/F
  - PLBD/RADIATOR
  - APS/FRCS OFF - VEH TEST

VAB

- MATE ORB/ET
- INSTALL:
  - ET TPS CLOSEOUT
  - SSME HEAT SHIELD
  - ORDNANCE
- TESTS
  - SSME I/F
  - CARRIER EJECT
  - SHUTTLE INTEG TEST

PAD

- MAJOR TESTS
  - PAD VALIDATION
  - PLUGS OUT
  - MPS LOAD/DETANK
  - CDDT
  - FRF
  - SYSTEM TEST
  - COUNTDOWN
- SERVICE
  - APU/HPU
  - HAZARDOUS FLUID SYSTEM
  - MPS PROPELLANTS
- LAUNCH

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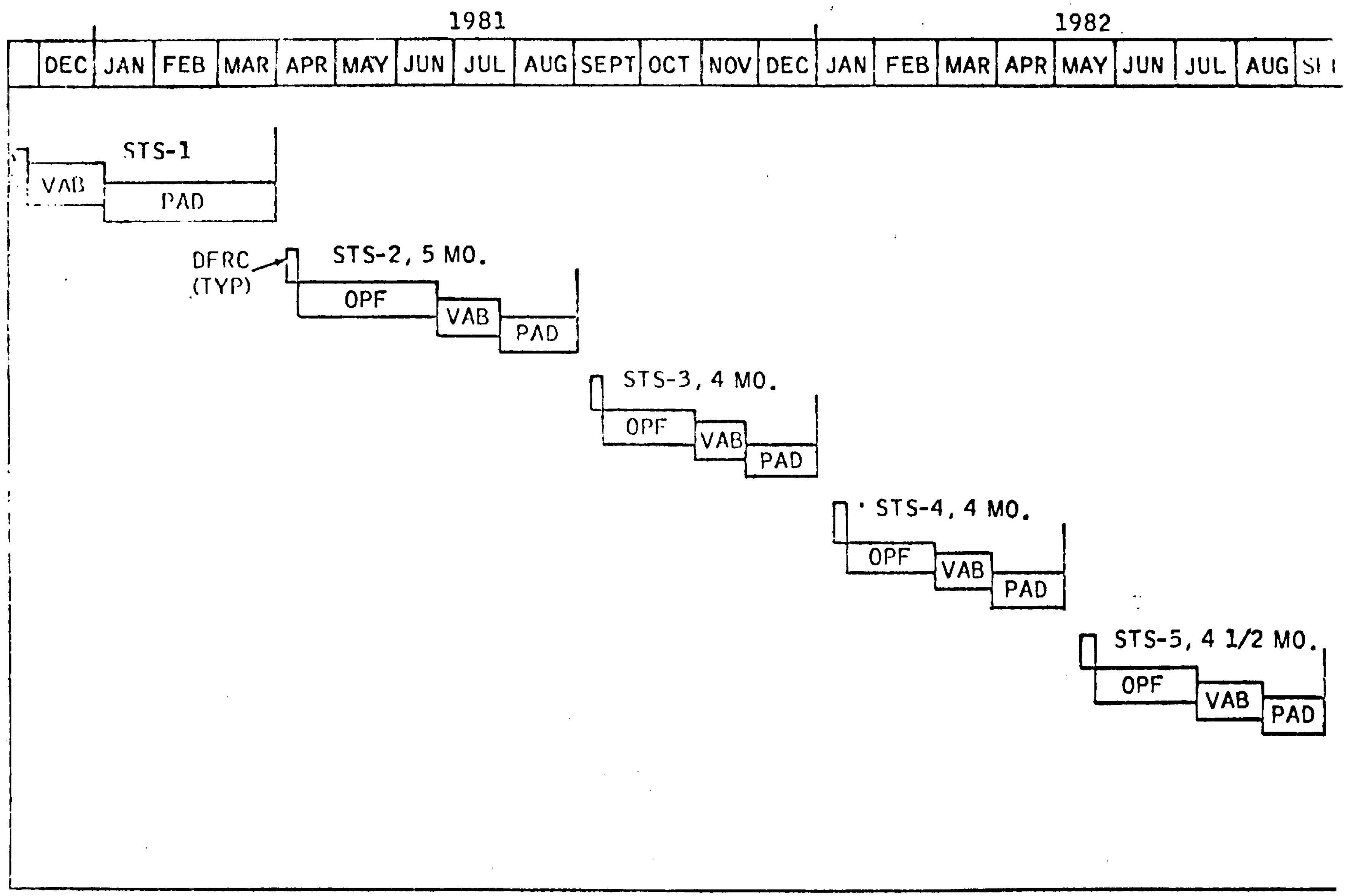
OFT FLOW PLANS



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STS-2 FLOW PLAN

WKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

DRFC
1 1/2 WKS

OPF
11 WKS

- TILE INSP/REPAIR
- MODIFICATIONS
  - 5.4 LOADS
  - MOVE DFI
  - INSTALL 3rd CRYO TANK SET
  - INSTALL OSTA-1, RMS, OEX EXPMTS
- TESTING
  - SYSTEMS TESTS
  - SSME INSP, LEAK TESTS
  - ORBITER INTEGRATION TEST
  - CREW EQUIPMENT I/F
  - APS/FRCS OFF - VEH TEST

VAB
4 WKS

- MATE ET/ORB
- INSTALL ORDNANCE
- SHUTTLE INTEG TEST

PAD
6 WKS

- MAJOR TESTS
  - PAD VALIDATION
  - SYSTEM TEST
  - COUNTDOWN
- SERVICE
  - APU/HPU'S
  - HAZARDOUS FLUID SYSTEM
  - MPS PROPELLANTS
- LAUNCH